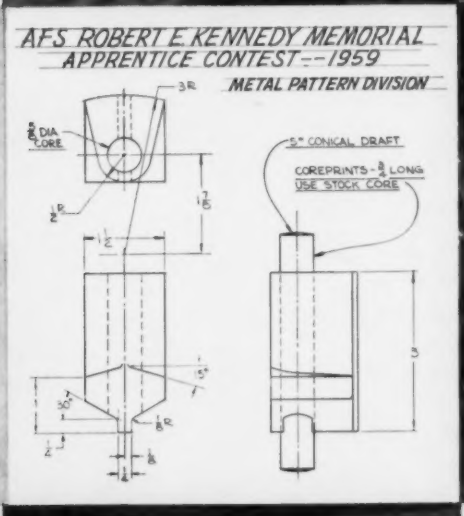
modern castings

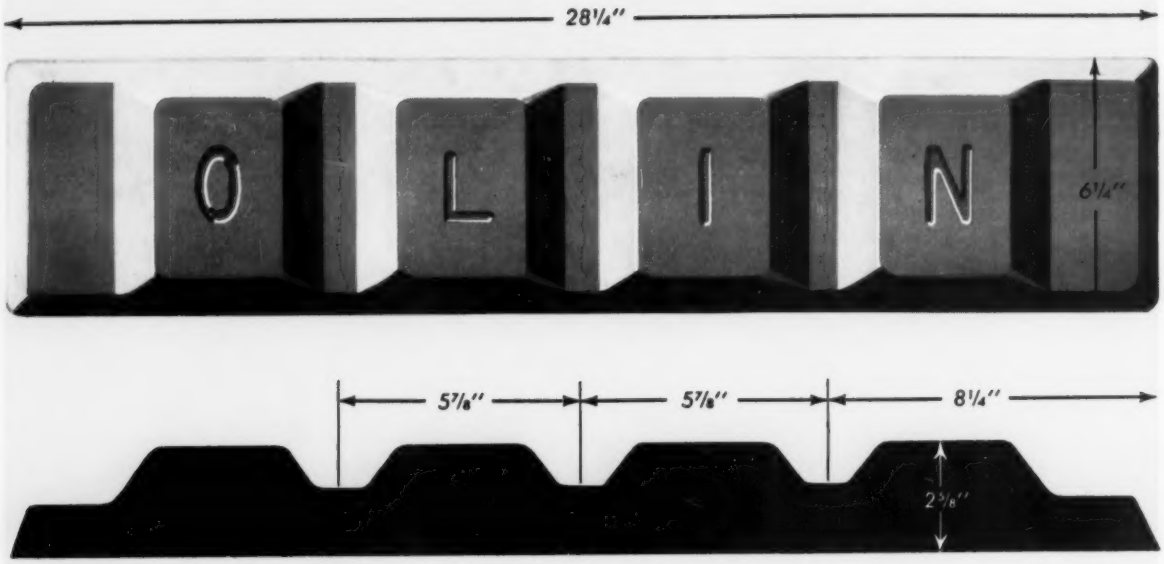
AFS MAY, 1959

- Official
- Convention
- Report
- Issue



- Engineered Castings Show Tour . . .
- Castings Congress Technology . . .
- Medals . . . Citations . . . Awards . . .
- Memorial Lecture . . .
- Elections . . .

YOU'LL FIND GOLD
IN THIS NEW 25 POUND OLIN ALUMINUM INGOT!



Now, a 25 pound ingot from Olin Aluminum. Consider its advantages for you!

Smaller size. Easier to store, easier to gauge metal supply for closer control.

Lighter weight. 25 lbs. vs. 30 lbs. Greatly increases handling efficiency.

Deeper notches. Easier to break. Saves time, eases work load.

More sections. 3 notches, 4 sections vs. 2 notches, 3 sections. Reduces waste.

Same price per pound as 30 lb. ingot. Olin Aluminum is the only prime supplier producing a 25 pound ingot, and at no additional cost.

America's new major aluminum producer, Olin Aluminum, is also the newest source of profitable ideas for foundrymen. Take advantage of it. Contact your nearby Olin Aluminum Sales Office or Authorized Distributor of casting alloys. Ask for our pig and ingot technical data bulletin. Metals Division—Olin Mathieson Chemical Corporation, 400 Park Avenue, New York 22, New York.

OLIN ALUMINUM

Symbol of New Standards of Quality and Service in the Aluminum Industry

Circle No. 145, Page 167-168

may, 1959
vol. 35, no. 5

modern castings

the technical magazine of the metalcasting industry

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MAY

April 29-May 1 . . American Society of Mechanical Engineers, *National Metals Engineering Conference*. Hotel Sheraton-Ten Eyck, Albany, N.Y.

April 30-May 11 . . *32d International Fair*, Brussels, Belgium.

4-5 . . American Society of Tool Engineers, *First Production Institute*. University of Wichita, Wichita, Kans.

4-6 . . American Society for Metals Savannah River Chapter, *Southern Metals Conference*. Bon Air Hotel, Augusta, Ga.

4-8 . . American Society of Training Directors, *Annual Conference*. Sheraton-Cadillac Hotel, Detroit.

8 . . Malleable Founders' Society, *Eastern Section Meeting*. Hotel Commodore, New York.

11-13 . . American Society of Mechanical Engineers, *Joint Conference on Automatic Techniques*. Pick Congress Hotel, Chicago.

13-15 . . National Industrial Sand Association, *Annual Meeting*. The Homestead, Hot Springs, Va.

17-21 . . American Ceramic Society, *Annual Meeting*. Palmer House, Chicago.

20-22 . . Society for Experimental Stress Analysis, *Spring Meeting*. Sheraton Park Hotel, Washington, D.C.

21 . . AFS Division Meetings, Executive Committees, Program & Papers Committees, *Annual Review*. Sherman Hotel, Chicago.

22 . . AFS Technical Council, *Annual Meeting*. Sherman Hotel, Chicago.

25 . . AFS Publications Committee, *Annual Meeting*. Sherman Hotel, Chicago.

25-26 . . Malleable Founders' Society, *Annual Meeting*. The Homestead, Hot Springs, Va.

25-27 . . American Society for Quality Control, *Annual Convention*. Public Hall, Cleveland.

25-28 . . American Society of Mechanical Engineers, *Design Engineering Show*, Convention Hall, Philadelphia.

27-28 . . American Iron and Steel Institute, *Annual Meeting*. Waldorf-Astoria Hotel, New York.

JUNE

1-2 . . New York University, College of Engineering, *Conference on Vacuum Metallurgy*. University Heights, N.Y.

9-12 . . Material Handling Institute, *Exposition*. Public Auditorium, Cleveland.

10 . . AFS Board *Orientation Meeting*, Central Office, Des Plaines, Ill.

11-12 . . AFS *Chapter Officers Conference*. AFS Headquarters, Des Plaines, Ill., and Sherman Hotel, Chicago.

15 . . AFS T&RI Research Committee, *Annual Meeting*. Chalfonte-Haddon Hall, Atlantic City, N.J.

16-19 . . Cornell University, *Industrial Engineering Seminars*. Ithaca, N. Y.

18-20 . . AFS *Foundry Instructors Seminar*. University of Illinois, Urbana, Ill.

21-23 . . Alloy Casting Institute, *Annual Meeting*. The Homestead, Hot Springs, Va.

21-26 . . American Society for Testing Materials, *Annual Meeting*. Chalfonte-Haddon Hall, Atlantic City, N.J.

22-26 . . Air Pollution Control Association, *Annual Meeting*. Hotel Statler, Los Angeles.

25-27 . . AFS *Penn State Foundry Conference*. Pennsylvania State University. University Park, Pa.

SEPTEMBER

24-26 . . AFS *Missouri Valley Regional Foundry Conference*. Missouri School of Mines, Rolla, Mo.

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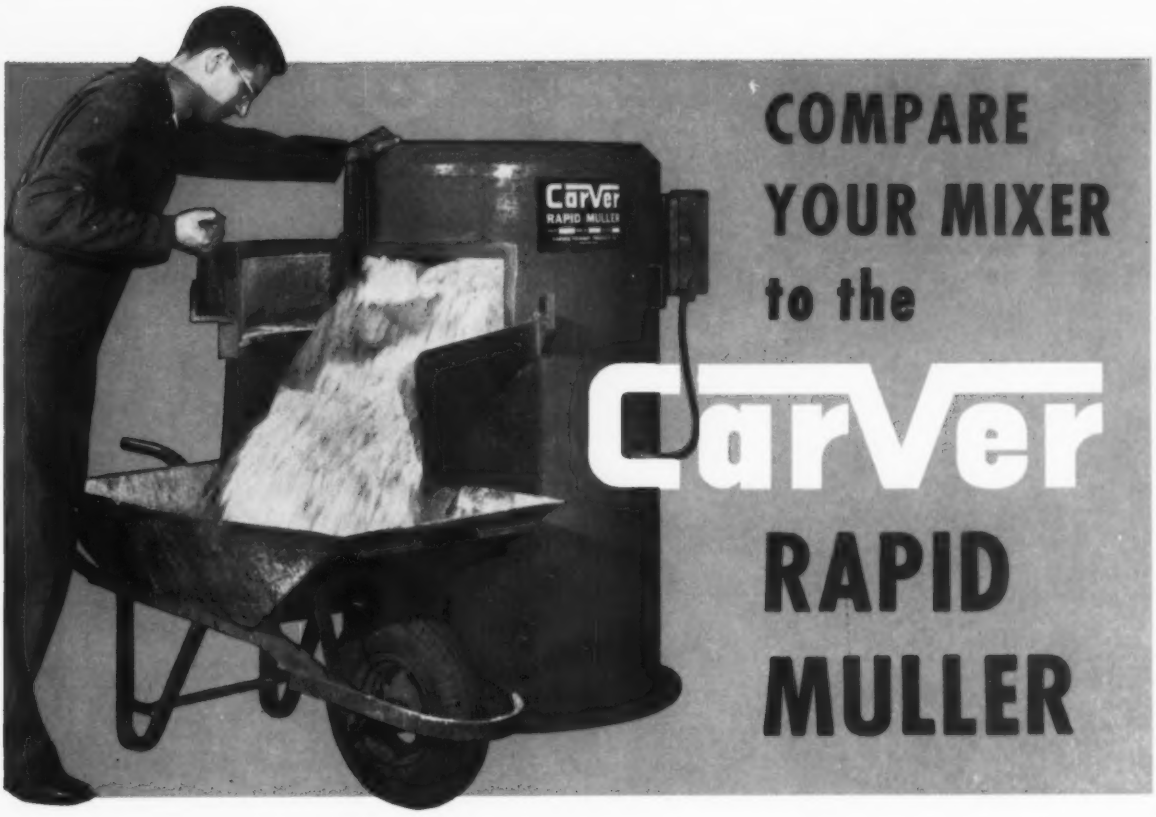

COMPARE YOUR MIXER to the Carver RAPID MULLER

COMPARE SPEED

With the Carver Rapid Muller, you get a batch *every 75 seconds*!

COMPARE PERFORMANCE

Absolutely NO lumps or wet spots. Each grain of sand receives an equal coating of binder.

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Patented self-cleaning mixing arm eliminates back-breaking cleaning chores.

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Carver Rapid Muller does a first-class job with molding sand, oil sand, resin sand, or CO_2 sand . . . any kind of binder.

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Your initial investment is three times lower than most mixers . . . yet you save as much as 30% in binder. Extreme simplicity of design, with only one moving part, keeps maintenance costs at a bare minimum.

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We're interested! Rush information on Carver Rapid Muller.

NAME _____ TITLE _____

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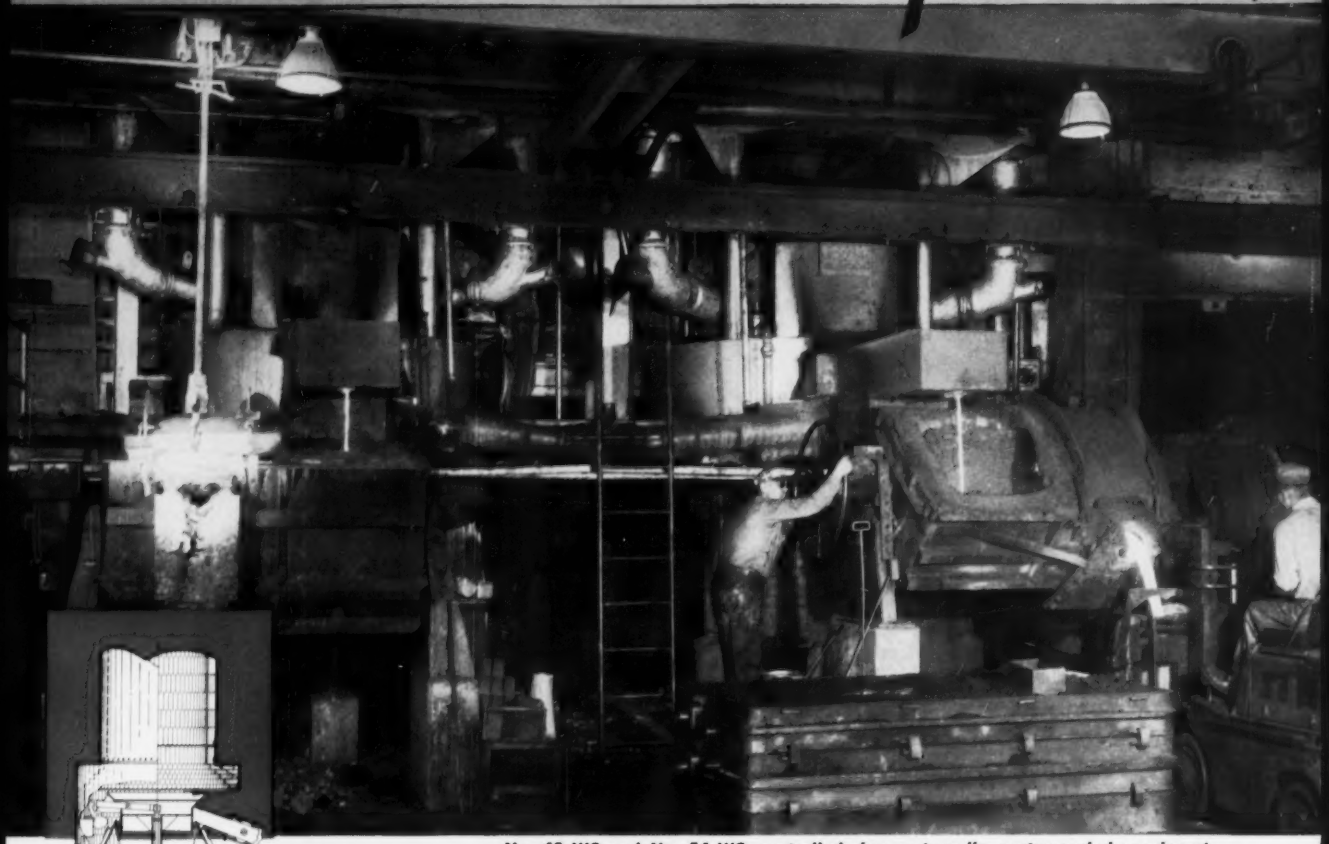
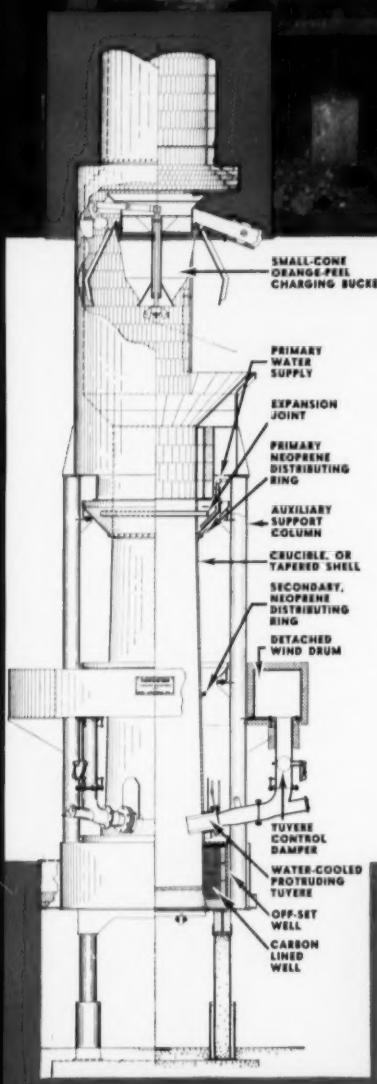
Circle No. 146, Page 167-168

MODERN Water-Cooled Cupolas for FLEXIBILITY





No. 48-WC and No. 54-WC, controlled slag, externally, water-cooled cupolas at Neenah Foundry — operating with basic, acidic or neutral slags as desired.

JOBBING FOUNDRIES CAN AFFORD IT, TOO!

"can't afford not to MODERNIZE," is the reason as given by Neenah Foundry Company for their change to controlled-slag, externally, water-cooled cupolas. Operating with protruding copper, water-cooled tuyeres and melting directly against the steel shell over-all benefits include:

- ***Greater flexibility and closer control of the melting processes . . .***
- ***Prolonged periods of melting . . .***
- ***Decreased costs for refractory and maintenance . . .***

These major advantages and many more are being enjoyed throughout the major industries and by foundries large and small.

At Neenah Foundry the 8 and 11 TPH MODERN, water-cooled cupolas are operated with basic, acidic or neutral slags as desired. Cupolas remain in continuous operation from Monday morning 'til Friday night. All types of gray iron melted along with base iron for nodular.

All these and other benefits are covered in new bulletin 149-A. Use the coupon or write to Modern Equipment Co., Port Washington, Wis.

MODERN

NEW Catalog 149-A Mailed on Request

Modern Equipment Co., Dept. MC-5, Port Washington, Wis.

☐ Mail to my attention new catalog 149-A ☐ Mechanical charging ☐ Dust abatement control ☐ Pouring equipment

Company .....

Street ..... Zone .....

City ..... State .....

My Name .....

the editor's report

by Jack Schaum

■ **The Honorable L. H. Durdin,** mayor of La Villita, 200 year old original settlement of San Antonio, is shown observing this official proclamation held by San Antonio Mayor J. Edwin Kuykendall at Texas Regional Conference. At the time of this honor, Durdin was president of AFS.

■ **Our Forum for Designers and Buyers** in the March issue of Modern Castings has proven so popular that we have run off 4000 extra copies as a special 24-page Bonus Section for further distribution. If you want to win buyers and influence designers, just send us their names and we'll see to it that they receive a complimentary copy.

■ **The CO_2 process** is now being used in 50 per cent of U. S. foundries . . . according to recent estimates.

■ **Hurry up . . . can't waste time . . .** so investment casters are speeding the cooling of large masses of wax by setting wax injection dies and inserts on dry ice to cool them down between shots . . . Now that the new ceramic shell mold for investment casting is permitting larger castings to be made, magnesium is being used for large dies that would be impossible to handle by hand.

■ **Now there's an idea . . .** just put a 3/4-in. thick slice of carbon electrode on that crucible of molten brass or bronze to stop zinc fuming . . . minimize heat loss . . . and skim dirt from metal surface during pouring. Pic shows carbon disk being placed in crucible of molten brass at Langsenkamp-Wheeler Brass Works, Inc., Indianapolis.

■ **American Society of Tool Engineers** has estimated that the metal which is whittled away in chips every year amounts to 15 million tons. Reduce this waste by casting to shape — why whittle when you can cast?

■ **Ventilation System Robs Molding Sand of Fines . . .** This daring theft is taking place in broad daylight, if your foundry exhaust system is doing its job. So watch your sieve analysis. If you need those missing fine particles to get good casting surface finish, you may have to add them back to the sand system.

■ **Small tapered down sprues** measuring only 1/4-in. at bottom are proving to be a big part of the answer to getting laminar flow of clean aluminum into the mold cavity. For faster fill, just use more sprues.

■ With the **aluminum engine block** scheduled to make its appearance in the 1960 cars there has been some skepticism about its ability to withstand frictional wear. Once again looking to overseas' experience, we learn that superior wear resistance has been imparted to cylinder bores of certain European cars by forcing chromium into the aluminum surface with hydrogen pressure. Process has been so successful that it has even permitted the use of **aluminum rifle barrels with chrome-coated bore!**

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Circle No. 147, Page 167-168

UNIVERSAL

REFRACTORY GATING COMPONENTS

• The *Thinwal* construction, providing as much as *35% lighter weight* will not spall nor erode in use even at temperatures up to 3250°F. They eliminate slag inclusions, stop rejects, reduce cleaning room time.

Standards and specifications bulletin available on request. Units for special applications quoted.

UNIVERSAL CLAY PRODUCTS CO.

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Circle No. 148, Page 167-168

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800 E. Illinois Street, Chicago, Ill. DElaware 9-6000.
(see Catalog Insert, Pages 148-155)
Distributors and Sales Offices
ALABAMA. Perfection Foundry Products of Birmingham, 131 45th Place, Birmingham. SAlem 1-1111.
CALIFORNIA. Hilbert Jenks Company, 2425 W. Monroe St., Berkeley. BAyside 4-3443.
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NEW JERSEY. Hudson River Core Oil Company, U.S. Route 1, P.O. Box 1390, Newark 1, N.J. DEvon 8-4700.
NEW YORK. Fred S. Hunter & Company, 1400 W. 31 St., New York 1. DAycrest 7-1310.
OHIO. Buckeye State Products Company, 1314 Cator St., Columbus. MAdison 4-8192.
PENNSYLVANIA. Perfection Foundry Products Corp. of Pennsylvania, 314 121st St., Pittsburgh 14. COalburner 7-3179.
TEXAS Alamo Core Oils Company, 14189 San Antonio St., Houston 11. CRockett 6-3289.
WISCONSIN. Badger Metals Service Company, 1400 E. Michigan St., Milwaukee. Riverside 3-9100.
PRESSED SEED BY-PRODUCTS COMPANY
Foundry Division, 102 E. Central Plaza, Cedar Rapids, Ia. HAwkeye 4-3000.
PROVIDENT METAL MACHINE COMPANY
1306 S. Main St., Sandusky, O. ISland 4-3012.
(See Catalog Insert, Page 113-114)
PRUDENTIAL ENGINEERING INC.
1604 Gibraltar Building, Philadelphia 118, Tyrone 7-1600
TRADE NAME LISTINGS
For Name of Supplier See Alphabetical Trade Name List
CORE OILS
Betol
C-J Oil
Collapsol
Crol
Flaxol
Golden Perfectol
Hades Oils
JJ Oils
Midconcoil
Minnesol
Perfectol
Platinum Perfectol
Pre-Oil
Pressedol
Sandpiper
Silver Perfectol
Caldwell-Jones

your COMPANY ! your PRODUCTS !

Are They on This List?

■ A list of thousands of trade names for foundry products has been compiled for the first issue of the AFS BUYERS DIRECTORY to be published Sept. 15—and more are coming in every day, according to Curtis Fuller, DIRECTORY Manager.

"Our alphabetical list of trade names will undoubtedly be one of the most useful sections to be contained in the new DIRECTORY," Fuller reported.

Foundry superintendents and purchasing agents will have at their fingertips for the first time a complete compilation of the myriad items used daily in the metalcasting industry.

The new DIRECTORY will have two complete trade-name sections. One section will list the trade names alphabetically and identify them by the manufacturer or supplier. The other section will classify them by type of product.

■ **Any supplier who has not returned his free product-listing form is urged to do so immediately. Suppliers who have not received their forms should request them by writing AFS BUYERS DIRECTORY, Golf & Wolf Roads, Des Plaines, Ill.**

When published in September, the BUYERS DIRECTORY will be a hard-covered book containing several hundred pages. AFS will distribute it free to every foundry superintendent in the United States and Canada. It will be the first complete directory of its type ever published for the metalcasting industry. All known suppliers and their products will be listed regardless of whether or not they advertise in the DIRECTORY.

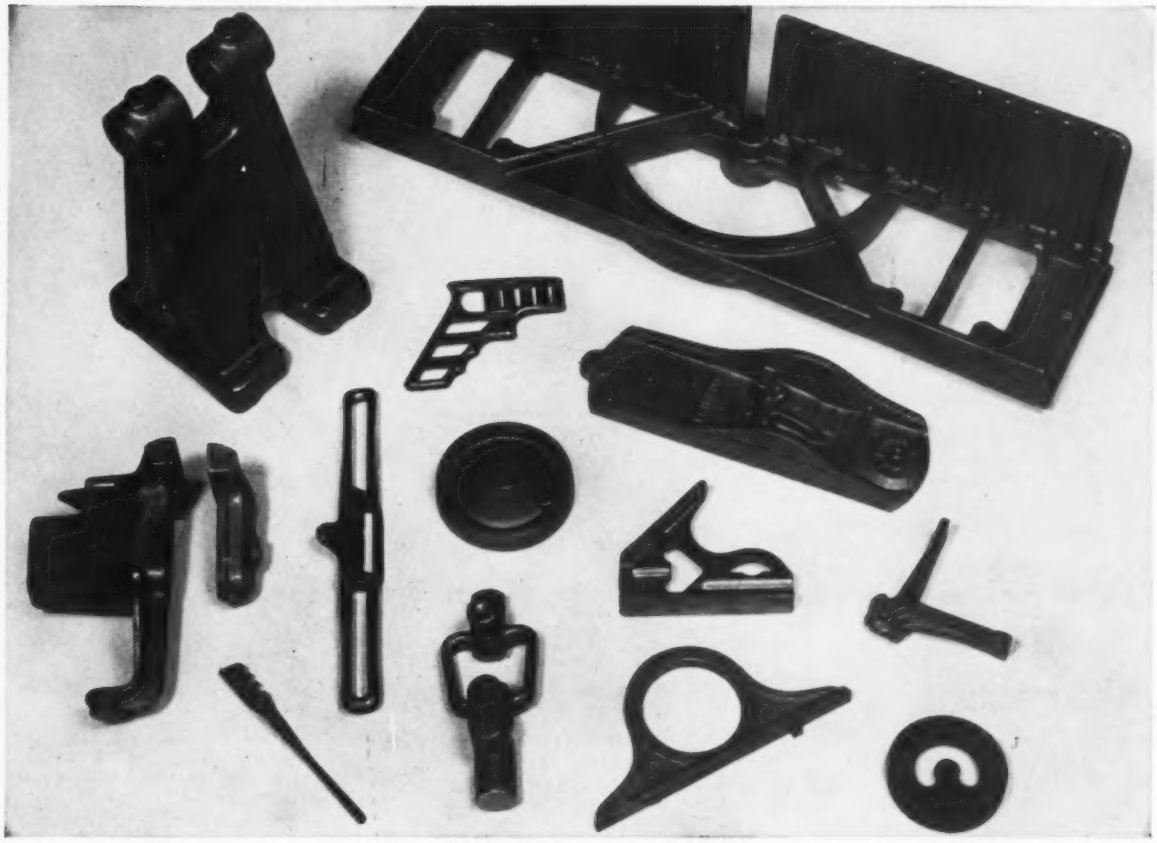
The DIRECTORY staff is busy compiling company names, distributor names, product listings and two types of trade-name listings from replies to an 8-page form mailed to all known metalcasting industry suppliers.

Supplementary product-listing forms, for products that were not originally covered, will be mailed to suppliers in a few weeks.

According to Fuller, "We have been most amazed by the number and variety of trade names. Many companies have more trade names in the DIRECTORY than they have product classifications because of the different grades and varieties of the same product, each of which has its own trade name. Our trade-name section is bound to be one of the most useful parts of the DIRECTORY.

■ Advertisers are advised to prepare catalog-type copy for the DIRECTORY, giving as complete details and specifications as possible about their products. Evidence from foundrymen who were interviewed before the DIRECTORY was planned indicates that they want as many hard facts as possible.

This is the kind of information that will be studied in minute detail by foundry superintendents and other purchasing men before they make their buying decisions.



Cast with Hanna iron, precision tool parts for jack planes, bench vises, saw handles and miter boxes require a minimum of machining because these gray iron castings are perfect and clean.

Why Millers Falls uses HANNA PIG IRON for hundreds of different precision-built tools

For more than 90 years Millers Falls Company has been manufacturing precision carpenter and machinists tools for home and industry. Some 1,500 different high quality tools are produced at the Greenfield, Massachusetts plant alone. More than 50% of the parts are made from gray iron castings containing Hanna malleable pig iron.

Many of these tools and tool parts require only shot cleaning before being assembled because of the close tolerance casting employed.

Quality, uniformity, strength and denseness, which are integral characteristics of Hanna pig iron, are reflected in the firm's record of perfect castings time after time.

Whatever you cast, large or small, there's a Hanna pig iron to do the job best. All regular grades, plus HANNATITE® and Hanna Silvery, are available in the regular 38-lb. pig or HANNATEN® 12½-lb. ingot. For the iron to suit your particular needs, call a trained Hanna representative for assistance.

Breaker slots on glass cutter castings require no machining. Illustration shows glass cutters immediately after shakeout.

THE HANNA FURNACE CORPORATION
Buffalo • Detroit • New York • Philadelphia
Merchant Pig Iron Division of
NATIONAL STEEL CORPORATION

Circle No. 149, Page 167-168

Build an idea-file for improvement and profit. The post-free cards on the last page will bring more information on these new . . .

products and processes

CORE SHOOTER . . bench model with 8-1/2 lb core capacity is said to be largest bench-type unit made. Features

stationary sand reservoir and single-lever control. *Hansberg Shooters Inc.*

For Manufacturer's Information Circle No. 1, Page 167-168

MOVING MOLD WEIGHTS . . with greater speed is said possible through special application of an air hoist. *Gardner-Denver Co.*

For Manufacturer's Information Circle No. 2, Page 167-168

ABRASIVE BELT MACHINE . . is claimed to be low-cost method of grinding inside surfaces. Unit uses 90-in. belt of one or two-in. width. *Grinding & Polishing Machinery Corp.*

For Manufacturer's Information Circle No. 3, Page 167-168

CAR SHAKER . . claims to empty railroad hopper cars ten times faster than manual methods. Electromechanical unit uses 4 hp motor. *Syntron Co.*

For Manufacturer's Information Circle No. 4, Page 167-168

AIR HAMMER . . for heavy cutting and chipping weighs 4 lb and delivers up to 2200 blows per minute. Air powered. *Superior Pneumatic Mfg., Inc.*

For Manufacturer's Information Circle No. 5, Page 167-168

CORE MANDREL . . attachment for automated hollow core machine is fully automatic. Said to provide close control of core wall thickness and exceptional uniformity of cure. The attachment consists of one or more internally heat mandrels plus operating mechanism and controls. *SPO, Inc.*

For Manufacturer's Information Circle No. 6, Page 167-168

REFRACTORY BRICK . . . specially developed for the aluminum industry is a chemically bonded, high alumina brick. *Refractories Div., H. K. Porter Co.*

For Manufacturer's Information Circle No. 7, Page 167-168

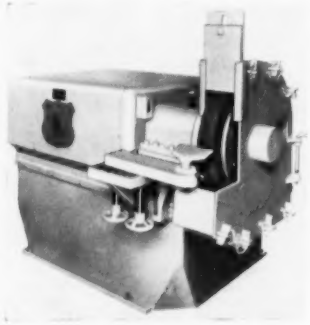
MOISTURE TESTER . . . for measuring moisture content of foundry sand completes test in 2-3 min. Portable tester shows moisture content directly on gage. *Alpha Lux Co.*

For Manufacturer's Information Circle No. 8, Page 167-168

ANGLE HEAD . . . pneumatic drills to reach corners, crevices, etc. Adjusts through 360 degrees. One-hand operated, 1/4-in. capacity. *Airetool Mfg. Co.*

For Manufacturer's Information Circle No. 9, Page 167-168

SNAGGING GRINDER . . is hydraulically driven to provide constant speed and power. Entirely new machine features patented speed changer which automatically maintains wheel surface



speed as wheel is worn down. Manufacturer promises reduced maintenance through elimination of mechanical drive. *U. S. Electrical Tool Co.*

For Manufacturer's Information Circle No. 10, Page 167-168

CERAMIC MAGNETS . . separate tramp iron from sand in new units using barium ferrite ceramic permanent magnets. *Stearns Magnetic Products.*

For Manufacturer's Information Circle No. 11, Page 167-168

AUTOMATIC TORCH . . travels straight line or circle, producing grooves or cuts of any desired depth or angle. Electric arc melts metal while air jet removes molten material. *Arcair Co.*

For Manufacturer's Information Circle No. 12, Page 167-168

PORTABLE GAS DETECTOR . . for testing the presence of gas in non-ferrous melts mounted on cart. Unit consists of vacuum pump, bell jar and sample cups mounted on stainless steel cart. *Harry W. Dietert Co.*

For Manufacturer's Information Circle No. 13, Page 167-168

MULTI-PURPOSE FURNACE . . is a 115-230 v top-loading electric unit adaptable for use as salt bath, melting, vertical muffle or crucible furnace. Maximum chamber temperature is 1900 F. Recommended for laboratory or small shop. *Thermo Electric Mfg. Co.*

For Manufacturer's Information Circle No. 14, Page 167-168

FLEXIBLE STEEL . . results from addition of new product to a mix of steel-filled epoxy resin. When additive is used, maker claims steel-filled epoxy is flexible as rubber. *Devcon Corp.*

For Manufacturer's Information Circle No. 15, Page 167-168

RESIN BLENDER . . is simple tool that lends precision and speed to task of blending pattern resins and hardeners. *Plaster Supply House.*

For Manufacturer's Information Circle No. 16, Page 167-168

CANADIAN-MADE . . cupola fluxing briquet is said to promote active fluid slag. Produced in four-lb briquets. *Scott Products.*

For Manufacturer's Information Circle No. 17, Page 167-168

VENTILATING SYSTEM . . for furnace areas uses heavy duty propeller-type exhausters to provide air change every 30 seconds. *Wigton-Abbott Corp.*

For Manufacturer's Information Circle No. 18, Page 167-168

NEW CASTABLE ALLOY . . . reportedly develops 40,000-50,000 psi tensile

Continued on page 10

Largest Electric Steel Foundry Casts Cities Service in Major Role

The LFM Manufacturing Company, Inc. praises "remarkable versatility" of Cities Service Core Oils

Today, a typical sampling of the work at The LFM Manufacturing Company might include: a one-piece railroad truck casting, 20 feet long and eight feet wide . . . giant 13,000 pound crankcase castings for 16-cylinder diesel generators . . . or intricate pump castings.

As might be expected, all of this requires one of the largest core rooms, covering 20,000 square feet of area, with 13 huge core ovens, scores of coremakers and a good many core oils.

But what fascinates LFM is not how many but *how few* different core oils they require, considering their vast production. Here they're quick to praise the remarkable versatility of Cities Service Delco #938.

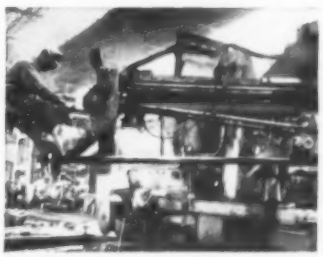
For at LFM, Cities Service Delco #938 is used in a surprisingly wide range of core applications with equally satisfactory results. Cores for the largest railroad casting or the smallest pump part are frequently made with this same oil.

Cities Service Core Oils provide this versatility because they can stand the long baking necessary for large cores and give the fast bake so vital to small cores. Shakeout properties are always excellent; smoke is minimal.

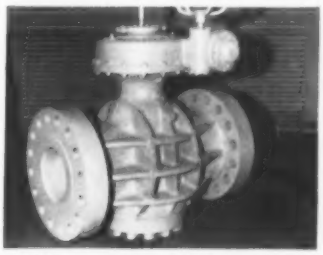
If you're looking for core oils of high quality and wide application, talk with a Cities Service Core Oil Specialist. Call the nearest office or write: Cities Service Oil Company, 20 N. Wacker Drive, Chicago 6, Ill.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS



Sandslinger is employed at LFM to swing out over giant molds and blast sand into them. Machine has capacity of 60 tons of sand per hour.



High Pressure Valve Body exemplifies diversification. LFM now makes parts for steel rolling mills, rock crushers, electric generators, as well as railroad parts. Cores for many are made with one oil—Cities Service Delco #938.

Circle No. 150, Page 167-168

NARCOLINE NARCOLINE

Slag-Resistant Plastic Refractory

NARCOLINE NARCOLINE

NARCOLINE Assures Cleaner Castings

It successfully resists the erosive and corrosive action of metals and slags, eliminating refractory inclusions from the casting.

NARCOLINE Facilitates Metal Flow

It resists graphite burnout under operating conditions, and maintains a lasting lubricated surface for easy metal flow.

NARCOLINE Assures Easy Slag Removal

It resists the wetting action of molten metal and slag, permitting ladles to be cleaned of solidified metal and slag with little effort.

NARCOLINE Easy to Install

It can be rammed to any desired shape with mallet or air hammer. Requires no special training to install.

Send for bulletin No. 106 Rev.

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General Offices, Cleveland 14, Ohio

DISTRICT SALES OFFICES:
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Philadelphia 2, Pa.
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NORTH AMERICAN REFRACTORIES, LTD.
191 Victoria Ave., South, Hamilton Ontario

Circle No. 151, Page 167-168

products and processes

Continued from page 8

strength and 35,000-37,000 psi yield strength. Elongation 6 to 10 per cent. Also said to possess good castability. *Reynolds Metals Co.*

For Manufacturer's Information Circle No. 19, Page 167-168

WATER REPLACES OIL . . as hydraulic medium for powering diecasting machines when new high-pressure, gear driven pumps used. *Aldrich Pump Co.*

For Manufacturer's Information Circle No. 20, Page 167-168

SHAKEOUT . . designed for 50-ton core knockout duty has been built. Machine is 10 x 12-ft 100-ton flask mogul style single unit. *Allis-Chalmers Mfg. Co.*

For Manufacturer's Information Circle No. 21, Page 167-168

WIRE THREAD INSERTS . . of stainless steel material make it possible to provide tapped holes in heat treated nonferrous castings. *Heli-Coil Corp.*

For Manufacturer's Information Circle No. 22, Page 167-168

EPOXY FOR 500 F . . new epoxy resin has heat resistance up to operating temperature of 500 F. Material is said to retain elasticity at higher temperatures. *Marblette Corp.*

For Manufacturer's Information Circle No. 23, Page 167-168

CONTOUR SAWS . . in line of redesigned equipment claimed to have greatly increased cutting rates. *DoALL Co.*

For Manufacturer's Information Circle No. 24, Page 167-168

EPOXY ANTI-FOAM . . chemical for reducing surface tension of liquid epoxy is packed in aerosol spray can. *Houghton Laboratories Inc.*

For Manufacturer's Information Circle No. 25, Page 167-168

2-MIN ANALYSIS . . of chemistry of steel alloys is possible with direct reading spectrograph. *Applied Research Laboratories.*

For Manufacturer's Information Circle No. 26, Page 167-168

SAND RECLAIMATION . . system in steel foundry is stated to reclaim 80 per cent of sand previously disposed of as waste. *Denver Equipment Co.*

For Manufacturer's Information Circle No. 27, Page 167-168

INDUCTION MELTING . . . unit contains power source, controls and all components necessary for operation of high-frequency induction furnaces and coils. *Inductotherm Corp.*

For Manufacturer's Information Circle No. 28, Page 167-168

SILICON COPPER . . . for use in producing silicon bronzes and brasses in your own foundry. *Continental Copper and Steel Industries, Inc.*

For Manufacturer's Information Circle No. 29, Page 167-168

PRECISION FORMING PROCESS . . . can reportedly produce up to 50,000 parts a day in almost all castable metals and alloys. Process is said to successfully combine basic advantages of investment casting with those of coining, cold forming, screw machine production, etc. Company also claims dimensional tolerances to plus or minus 0.001-in. per in. and superior surface finish. *Casting Engineers Inc.*

For Manufacturer's Information Circle No. 30, Page 167-168

ALUMINUM SOLDERING ROD . . . requires no flux, washing or wire brushing. No cleaning needed, either before or after use, officials report. Applied by rubbing across joints which have been heated. *Air Reduction Sales Co.*

For Manufacturer's Information Circle No. 31, Page 167-168

SILICONE MOLD RELEASE . . . and lubricant reportedly eliminates sticky and marked molds in shell molding operation. *Para Products.*

For Manufacturer's Information Circle No. 32, Page 167-168

CONTINUOUS BLENDER . . . for continuous-flow mixing and discharging of foundry sand and additives. *Johnson-March Corp.*

For Manufacturer's Information Circle No. 33, Page 167-168

CRANE MAINTENANCE . . is a safer job when a power hoist is installed on a boom over a bridge crane. Hoist is used in servicing heavy motor and truck parts. *Ingersoll-Rand Co.*

For Manufacturer's Information Circle No. 87, Page 167-168

TWO PALLET LOADING . . system for abrasive blasting cleaning equipment is said to reduce cleaning time to minimum. *Pangborn Corp.*

For Manufacturer's Information Circle No. 88, Page 167-168

METAL PROCESSING . . . barrel for foundry cleaning and finishing operations features door which opens and closes automatically. Also, automatic discharging. *Hanson - VanWinkle - Munning Co.*

For Manufacturer's Information Circle No. 89, Page 167-168

EPOXY GASKETS . . . designed for head of core blowing machines and for exterior periphery of core boxes; reportedly prevents sand from blowing out during coreblowing operation. *Furane Plastics, Inc.*

For Manufacturer's Information Circle No. 34, Page 167-168

TEST PROPERTIES . . . of metal. Physical properties obtained 4 min after test bar cools, according to company officials, with transverse tester. Requires

Continued on page 16

big league hitters

study the pitcher's stuff. you can improve your average by studying the information available by circling numbers on card, last page.

Circle No. 152, Page 167-168

Knight professional foundry engineering

The key men in the Knight organization have from 10 to 25 or more years of successful experience in some phase of foundry management, production, engineering or equipment. The coordination of each man's specialized experience, plus a realistic "working type" approach, enables the Knight organization to supply foundry management with reliable, practical assistance on virtually all foundry problems. The Knight organization has successfully completed more than 400 assignments in every type of foundry —grey iron, steel, malleable, brass and bronze, magnesium, and aluminum. These foundries are producing castings from a few ounces to 50 tons and from 1 to more than 1,500 tons of castings per day. Green sand, dry sand, cement, plaster, "shell" molds, permanent mold, centrifugal, die casting and investment casting operations all have been served by Knight.

Working closely with clients' staffs, Knight Engineers have assisted clients to audit operations, improve organization and management, establish cost and incentive systems, modernize methods and facilities, and design complete new plants, with economically sound mechanization and automation in varying degree. Knight is working with the most modern foundries in the United States, Canada, Europe and South America and is staffed to do a "turnkey" job.

Knight Engineering

From the solution of a single problem in one department . . .

EVIDENCE OF EXPERIENCE

The Knight engineering organization, with successful experience in more than 400 foundry assignments here and abroad, is equipped to assist managements with a wide range of foundry problems. In many instances, Knight has assisted the client to modernize methods and facilities, then established the new organization and procedures for adequate control (including cost control), and new incentives based on the work content of the job.

Lester B. Knight & Associates, Inc.

MANAGEMENT, INDUSTRIAL AND PLANT ENGINEERS

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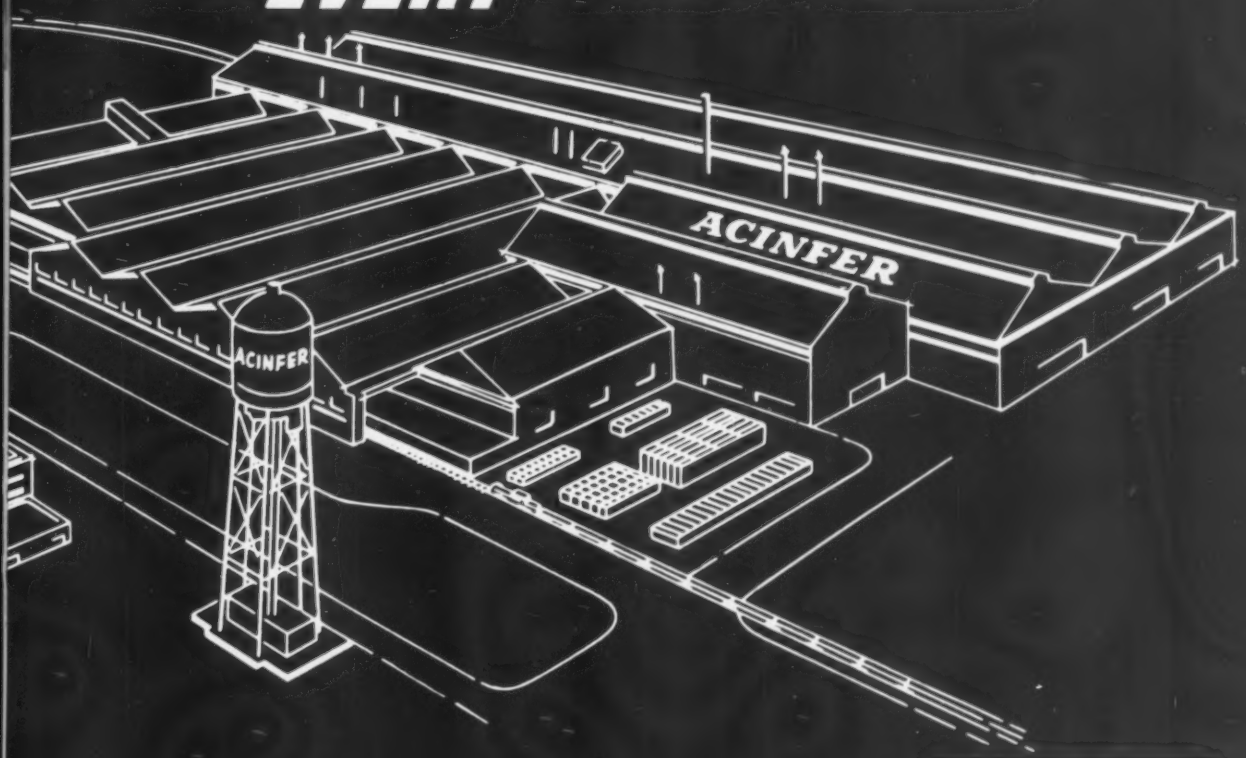
...FOR *EVERY* FOUNDRY PROBLEM



The Acinfer, S.A. plant, engineered by Knight, was awarded a Diploma of Honour by McGraw-Hill's "Ingenieria International Industria" as the most modern industrial plant in the Argentine Republic.

KNIGHT SERVICES INCLUDE:

Foundry Engineering
Architectural Engineering
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Methods
Materials Handling
Automation
Survey of Facilities
Marketing

. . . to the design, layout and construction management of complete new plants

For others, as in the case of Acinfer, the largest grey and malleable iron foundry in South America, Knight Engineers had overall responsibility from planning to successful operation. This comprehensive assignment involved basic designing, specification, procurement and supervision of installation of facilities, procurement and supervision of operating personnel. Similar broad foundry assignments have been carried out in the United States, Canada and Europe.

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A partial list of

Knight clients

for professional

foundry engineering

- **Acindar, S.A.**
  Buenos Aires, Argentina
- **Acinfer, S.A.**
  Villa Constitucion, Argentina
- **Alloy Steel Products Co.**
  Linden, N. J.
- **American Brake Shoe Company**
  Chicago and St. Louis
  Buffalo and New York
- **American Malleable Castings Company**
  Marion, Ohio
- **American Radiator & Standard Sanitary Corp.**
  Baltimore and Louisville
- **Appleton Electric Company**
  South Milwaukee, Wisc.
- **Belle City Malleable Iron Company**
  Racine, Wisc.
- **Bergische Stahlwerke A.G.**
  Remscheid, Germany
- **Buckeye Steel Foundry Co.**
  Columbus, Ohio
- **Buderus 'sche Eisenwerke**
  Essen, Germany
- **Canadian Car and Foundry Company, Ltd.**
  Montreal, Quebec
- **Chrysler Corp.**
  New Orleans, La.
- **C. K. D.**
  Blansko, Czechoslovakia
- **James B. Clow & Sons Co.**
  Birmingham, Ala.
- **Combustion Engineering, Inc.**
  Chattanooga, Tenn.
- **Crane Co.**
  Chicago and Chattanooga
- **Dalton Foundries, Inc.**
  Warsaw, Ind.
- **Dayton Malleable Iron Co. (3 plants)**
  Dayton, O.
- **Der Stahl- und Temperguss A. G.**
  Traisen, Austria
- **Dominion Foundries & Steel Limited**
  Hamilton, Ontario
- **Electric Steel Foundry Company**
  Portland, Ore.
- **Erie Malleable Iron Company**
  Erie, Pa.
- **Fahralloy Canada Limited**
  Orillia, Ontario
- **Fairbanks, Morse & Co.**
  Kansas City, Kan.
- **Federal Malleable Co.**
  Milwaukee, Wisc.
- **General Railway Signal Company**
  Rochester, New York
- **General Steel Castings Corp.**
  Eddystone, Pa.
- **Goetzewerke A/G**
  Burscheid, Germany
- **Gunite Foundries Corporation**
  Rockford, Ill.
- **Hammond Brass Works**
  Hammond, Ind.
- **Hauts-Fourneaux et Fonderies**
  Halbergerhutte
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- **Haynes Stellite Company**
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- **Hershey Corporation**
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- **A. Y. McDonald Manufacturing Company**
  Dubuque, Iowa
- **Mannesmann-Meer A.G.**
  Munchen, Gladbach, Germany
- **Moline Malleable Iron Company**
  St. Charles, Ill.
- **Mueller Co.**
  Decatur, Ill.
- **National Roll & Steel Foundry Co.**
  Avonmore, Pa.
- **Ohio Injector Co.**
  Wadsworth, Ohio
- **OPW Corporation**
  Cincinnati, Ohio
- **Pittsburgh Steel Foundry Corporation**
  Glassport, Pa.
- **Ransohoff, Inc.**
  Hamilton, Ohio
- **Scullin Steel Company**
  St. Louis, Missouri
- **Sibley Machine & Foundry Corporation**
  South Bend, Ind.
- **Spojene Tovarny Na Obrabeci Stroje**
  Brno, Czechoslovakia
- **Stavanger Electro-Staalverk A/S**
  Jorpeland, Norway
- **Stockey & Schmitz**
  Gevelsberg, Germany
- **Stockham Valves & Fittings**
  Birmingham, Ala.
- **Sulzer Bros. Ltd.**
  Winterthur, Switzerland
- **Superior Steel & Malleable Castings Co.**
  Benton Harbor, Mich.
- **Universal Castings Corporation**
  Chicago, Ill.
- **Wagner Malleable Iron Company**
  Decatur, Ill.
- **Walworth Company**
  Kewanee, Ill. and Boston, Mass.
- **Wellman Bronze & Aluminum Company**
  Cleveland, Ohio
- **Woodruff & Edwards, Inc.**
  Elgin, Ill.
- **Worthington Corporation**
  Harrison, N. J.

At Magcobar's Des Plaines, Illinois, laboratory, A. H. Zrimsek uses modern methods for foundry sand research.

SCIENCE and SAND

. . . Recipe For Progress

In new laboratories at Des Plaines, Houston and Greybull Magcobar technicians are busy with silica, bentonite, water and a host of other ingredients, taking the guesswork out of sand formulas. Applying modern research methods, these scientists are *proving* the "hows" and "whys" of foundry sand practice.

Magcobar invites the technical and research groups of the American Foundries to use Magcobar facilities for the solution of various industry-wide problems relating to sands.

Write Des Plaines for our latest foundry technical bulletins. Look to Magcobar, producers of YELLOWSTONE bentonite, for further revealing recipes for progress.

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YELLOWSTONE
BENTONITE

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Magcobar technicians in the company's big research laboratories in Houston strive for constant improvement of Magcobar products.

This Magcobar plant at Greybull, Wyoming, where YELLOWSTONE is mined and processed, is the world's largest producer of bentonite, and includes a complete quality-control laboratory.

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with MARSHALL ENCLOSED-TIP THERMOCOUPLES

. . . for strong, dense, uniform castings from every melt!

Reduce scrap rejects, misruns, cold-shuts . . . achieve consistently high quality castings! Marshall Enclosed-Tip Thermocouples indicate instantly and accurately "when" to pour brass, bronze, aluminum, or magnesium melts. Frequent, regular, exact temperature readings help avoid shrinkage porosity, gas porosity, dross . . . produce better casting finishes . . . control aluminum grain size.

Dependable, easy-to-use Marshall Thermocouples *take interior temperatures deep within the melt.* Tip can be stirred to speed reading, giving *true temperature in about 20 seconds.* Pyrometer always indicates *steady, accurate reading.* Thermocouple wire can't become contaminated from melt or short-circuited by slag. Tip withstands scores of immersions before replacement is necessary. Mail coupon for catalog today!

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Furnace Type (above) . . . lengths up to 10 ft., for use with Stationary Pyrometer.
Ladle Type (left) . . . for use with Portable Pyrometer.

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Please rush Catalog which fully describes Marshall Enclosed-Tip Thermocouples!

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STREET ADDRESS_____
CITY_____

Circle No. 154, Page 167-168

products and processes

Continued from page 10

no machining of transverse bars and no special training for operation. Handles 12 and 18-in. bars. *Pasadena Hydraulics, Inc.*

For Manufacturer's Information Circle No. 35, Page 167-168

INDUCTION MELTING FURNACES . . . push-out and tilting-type, designed to offer high melting speeds and accurate metallurgical control. Fifty to 5000-lb capacity. *Westinghouse Electric Corp., Industrial Electronics Dept.*

For Manufacturer's Information Circle No. 36, Page 167-168

GROUTING CEMENT . . . new, fast-setting, for securely fastening machinery, hand-rails, seats, fixtures or equipment to concrete by means of anchor bolts. *Garland Co.*

For Manufacturer's Information Circle No. 37, Page 167-168

QUENCH TANK LOADING . . is facilitated by "elevator" fork lift truck that

can lower its load 84 in. below floor level. *Towmotor Corp.*

For Manufacturer's Information Circle No. 38, Page 167-168

TRAMP IRON . . is removed from sand system by permanent magnetic plate separators located over conveyors. *Eriez Mfg. Co.*

For Manufacturer's Information Circle No. 39, Page 167-168

DESANDING AND DESCALING . . of iron castings by salt bath treatment is said to improve machining and prevent operational failure of closely-fitted moving parts. *A. F. Holden Co.*

For Manufacturer's Information Circle No. 40, Page 167-168

SPOT BLASTING . . is feature of small sand blast unit that can reach into confined areas. Operates on 100 to 185 lb pressure. *A. L. C. Co.*

For Manufacturer's Information Circle No. 41, Page 167-168

CALCIUM SILICON POWDER . . . for use in production of spun pipes, as alloy addition, for thermit welding and to reduce feeder head losses, according to manufacturer. *Hummel Chemical Co.*

For Manufacturer's Information Circle No. 42, Page 167-168

Checking Regulus I surface-to-surface missile prior to launching from experimental cart. For the use of Ni-Cr-Mo steel castings in the launching cart, Chance Vought was judged a National Award Winner in the Third Product Development Contest conducted by the Steel Founders' Society of America.

How castings of 4330 nickel-alloyed steel help boost a missile up, push assembly cost down

20-Ni-Cr-Mo steel castings replace 73 detail parts, eliminate 300 hardware items in new launching cart

Regulus I, made by Chance Vought, is normally boosted skyward from a rail launcher. The Navy, however, wanted a more economical launching technique that would utilize a carrier's powerful catapults . . . that would also simplify handling of the missile aboard ship.

The answer was the expendable catapult cart you see above.

The carts, also made by Chance Vought, are assembled with 20 cast 4330 steel cluster joints welded to tubing of the same material. These castings replaced 73 detail parts required in the plate-type fittings of the experimental units used to prove the idea. They also eliminated 300 hardware items, such as nuts and bolts. Assembly is easier, and far more economical.

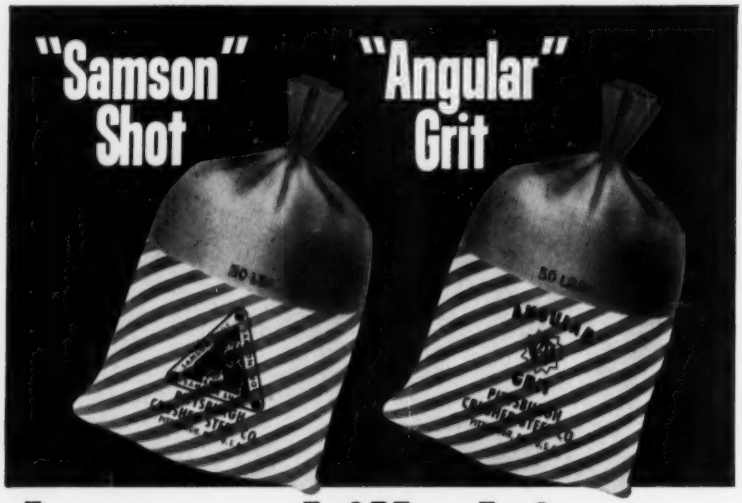
Why Ni-Cr-Mo steel for the castings? The 4330 composition of 1.8% Ni .65% Cr. .25% Mo heat treated to 125,000 and 150,000 psi gives these castings the combination of high strength and great toughness needed to stand up to the tremendous shock of take off.

What about your product? Can it use the economy, high strength, and shock resistance offered by Ni-Cr-Mo steel castings? You can get complete information by writing:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER



better chilled iron abrasives..and why

We have made metal abrasives since 1888. We pioneered their use in place of silica sand for blast-cleaning. We have "grown up" with their expanding use, acquiring unequalled know-how and experience along the way. *No other maker of metal abrasives has an equal experience record.*

Since 1937 we have carried on a continuous program of research for improvement of metal abrasives with one of America's foremost metals research organizations. *No other metal abrasives maker has an equal record of research.*

Ours is the only plant in America using the HOT BLAST MELTING process for production of metal abrasives; this, plus fully automated processing, provides the complete quality control that assures uniformity of chemistry, structure and hardness from one lot to another —assures the user of obtaining the same high performance from every shipment of Samson Shot and Angular Grit.

Experience, research, superior manufacturing facilities make these better chilled iron abrasives cheaper to use than those made to sell at a price.

MALLEABRASIVE Shot and Grit

TRU-STEEL Shot

LEADERS in development of PREMIUM-TYPE ABRASIVES

The two best known names in premium abrasives were developments of two of our subsidiaries. MALLEABRASIVE, the first malleablized type of metal abrasive ever produced, set the pace for development of all other makes of premium abrasives. TRU-STEEL Shot was the first high-carbon all steel shot produced to meet demand for this specialized type of abrasive.

One of these products may do your blast-cleaning job better, and at lower cost. Write us for full information.

PITTSBURGH CRUSHED STEEL CO.

Arsenal Sta., Pittsburgh 1, Pa.

Subsidiaries: The Globe Steel Abrasive Co., Mansfield, Ohio (Malleabrasive)
Steel Shot Producers, Inc., Arsenal Sta., Pittsburgh (Tru-Steel)

Circle No. 156, Page 167-168

have you read . . . ?

U. S. Dept. of Commerce, Office of Technical Services. **Investigation of Nodular Cast Iron Manufactured in the Springfield Armory Casting Laboratory.** U. S. Government Printing Office. Washington, D. C. (1957) PB 131399. 45 p.

The object was to determine a satisfactory technique for producing as-cast pearlitic nodular iron in thin-wall castings (less than one-half inch in thickness) using magnesium silicon as an inoculant. The investigation consisted of several phases: the preparation of hypoeutectic and hypereutectic irons; heat treatments for the castings produced; and various metallurgical examinations, physical tests and chemical analyses. Other agents added were ferromanganese, tellurium and ferrosilicon.

Gregory, Edwin. **The Structure of Steel.** Philosophical Library, N.Y. (1957) 176 p.

A simple, non-technical explanation for students, engineers and buyers . . . of the metallurgical structure of the various steels and steel alloys. The basic chemistry of iron and steel is outlined, with references to the cooling from the liquid state. Impurities found in steels and their effects are explained, as well as the effects of the various processes of mechanical working. The wide range of modern test methods is well covered. There is a chapter on heat-treatment processes, one on corrosion (stainless steels), and one on structural effects of mechanical working.

Rusinoff, S. E. **Mathematics for Industry.** American Technical Society, Chicago (1958). 565 p. (AFS code 510)

Mathematical principles are given an ultimate application to practical shop problems. Each principle is developed in a step-by-step sequence. Each problem is selected for its practicality. There is a chapter on engineering computations, along with chapters on fundamental math, such as: basic arithmetic, algerithms, use of the slide rule, engineering graphs, computation of automatic controls for automation, and problems in inspection and quality control.

Rusinoff, S. E. **Manufacturing Processes—Production.** American Technical Society, Chicago (1957). 560 p. (AFS code 621.75)

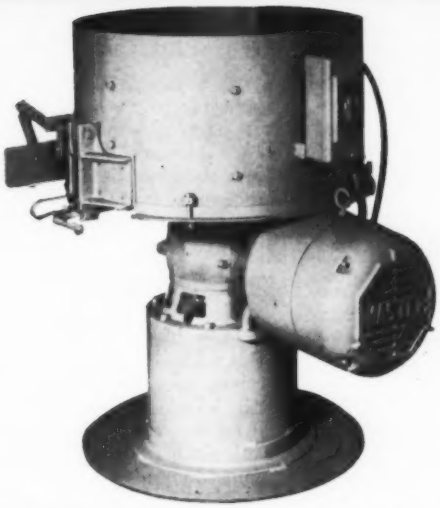
A comprehensive study of the machinery used in the fabrication of metal parts. Covers the selection and use of machine tools and related equipment, recent developments in production methods, and the latest techniques in safety engineering. How to adapt automatic methods to metal cutting is told, as well as lathe and milling machine operations. There is a chapter on shapers, slotters, and planers; a chapter on metal-sawing and metal-filing machines; one on broaching machines and their operation; another on gears and gear manufacturing.

only quality equipment
can do a quality job on...

CO_2 SAND*

*(or air-setting, resin-bonded
and oil-bonded core sands)

B&P WHIRLMIX



A SIZE FOR YOUR JOB—Batch capacities of 375 and 750 lbs.—hourly capacities to 22,500 lbs. of fully prepared sand.

	Batch Capacity	Approx. Hourly Capacity Oil and resin-bonded sand	Approx. Hourly Capacity CO_2 and air-setting sand	Motor HP
Model 375	375 lbs.	7500 lbs.	11250 lbs.	5 HP
Model 750	750 lbs.	15000 lbs.	22500 lbs.	10 HP

COMPACT AND LOW COST

The cost is low—well within the budget of even the small foundry—minimum space requirement, too. Yet, capacity is high—two compact, productive models.

FAST AND THOROUGH

Three minute cycle for oil bonded core sands—two minute cycle or better for most CO_2 and air-setting sands. Thorough uniform mixing with *no lumps and no crushed grains*—full control of sand properties.

EASY TO INSTALL—EASY TO USE

No pits or foundations for installation—just plug in. Low loading height, high discharge makes it easy to use.

ECONOMICAL TO OPERATE

Low power requirement—short cycle keep operating costs low. Clean rugged construction, replaceable wearing parts, totally enclosed drive keep maintenance costs at a minimum.

BEARDSLEY & PIPER

Div. Pettibone Mulliken Corp. • 2424 N. Cicero Avenue
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Circle No. 159, Page 167-168

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TEMPERATURES
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The only self-contained direct-reading optical pyrometer for quick temperature readings of molten iron, steel, monel, etc.

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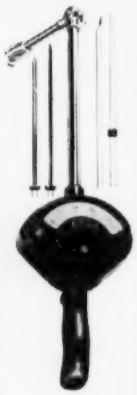

Quickly gives precise temperatures of molten non-ferrous metals. Thermocouples interchanged instantly. Ranges from 1000° to 2500°F.

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INSTRUMENT
CO., INC.
BERGENFIELD 10, NEW JERSEY

Circle No. 158, Page 167-168

Diversification of Processes

by SAM HODLER
Golden Foundry Co.
Columbus, Ind.

Editor's Note: This article contains highlights excerpted from a talk presented at the 1958 Purdue Metal Castings Conference.

■ Nothing can destroy a business so completely as a new and better product in the hands of a competitor. It is axiomatic to say that our future is directly geared to those who are leading the way. Are we only doing a good defensive job of protecting what we already have by reducing prices to meet competition, or do we have an aggressive offense that will put us out in front?

This aggressive offense can be achieved by three fundamental approaches, (1) technical research, (2) product development and (3) education, both in and out of the plant.

The country is full of weldments, machined parts, forgings and fabrications that should be castings. What, if anything, are we doing to get them into the foundry? One approach is to diversify our processes and apply a variety of processes to a single end—the production of castings.

WHY DIVERSIFY

The basic answer to the question, "Why diversify?," is simple: **no one process can do all jobs best.** Best for whom? Best for you and best for the customer. Some of our new processes are more economical; they provide a larger margin of profit for the foundry operator. Some of our new processes cost more; but, they either:

1) Make the job more profitable, or cheaper, to the customer.

2) Give the customer greater satisfaction, so that he is less tempted to switch to something else.

3) Give the customer something so much cheaper that he switches from another process to castings.

If these are valid arguments, then it follows that some foundries will diversify their production methods. So, another answer to "Why diversify?", is: **to meet competition.** If the foundry down the street is doing it, you had better get ready to do it too.

PERMOLD AND DIE CASTING

A good many parts formerly made in green sand jolt squeeze shops have already been converted to permanent molding and die castings. Sand molded, chilled iron car wheels have been extensively replaced by variously fabricated steel wheels. Automotive parts in considerable quantity have been converted from sand castings to permanent mold castings.

So far as iron foundrymen are directly concerned, the competition from improved, light weight aluminum alloys has been extensive. But the aluminum foundrymen themselves, who make sand castings, have found many of their long running jobs are converted to die casting.

SHELL CORES

We, at Golden Foundry, have extensively investigated the widely adopted shell core process. Cost figures do not indicate that all shell cores are cheaper to make than oil sand cores; as a matter of fact, some cost more. But the cost of the core itself is only a part of the story.

The quality of the cast surface next to a shell core can be made consistently better than that of other cores. Cleaning the casting made with a shell core is always easier. Dimensions of the cored hole are held to closer tolerance. This becomes even more important in cored assemblies because the variances in ordinary cores, which tend to multiply in core assemblies, are absent.

CO_2 CORES AND MOLDS

Another new process for which we found some considerable application and expect to find more, is CO_2. We like it especially for larger cores and we use it where indicated, for molding. The CO_2 process has been much slower to develop, and less generally applicable to our work than shell.

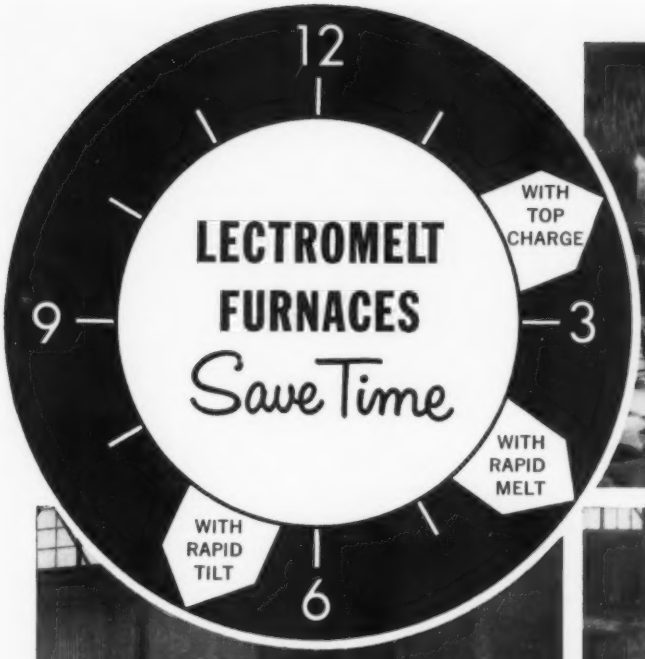
It offers a method of holding much closer tolerances than any of our old established practices with high speed production; it is capable of providing an excellent finish; and it is remarkably free from common defect causes.

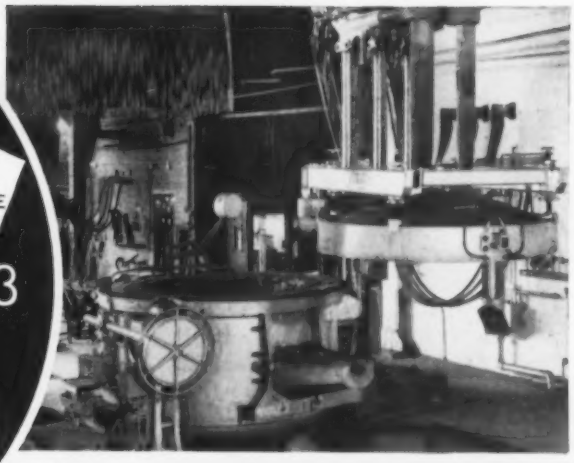
OTHER PROCESSES

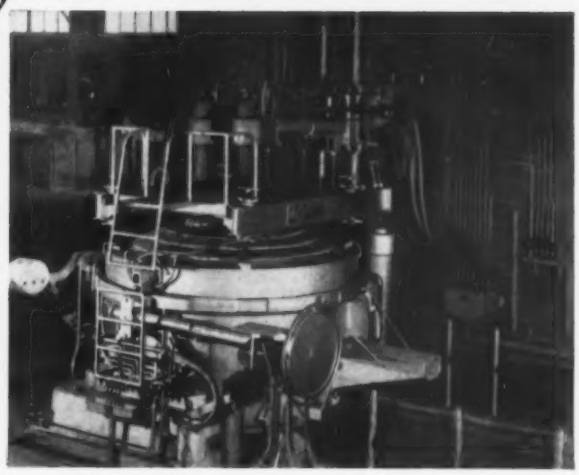
In more specialized jobs there are methods like the Shaw process for close tolerance and ultra smooth finish casting. Also, the air setting cores appear to offer considerable economy in the heavy core field. Each of these methods has either greater foundry economy or a better cast product.

Some of these costs naturally are fairly high but the need to survive may make this cost look smaller to the operator who wants to stay in business.

In speaking of quality, there was a poll taken of 640 casting buyers to determine why they placed orders with certain foundries. It might be of interest to some of you that quality represented 66 per cent, price 18 per cent, delivery 15 per cent and service 1 per cent.







When you melt... LECTROMELT*

TOP CHARGING provides smooth, fast turn-around in furnace operation—less downtime between heats and less heat loss. Linings and electrodes last longer.

HIGH POWER INPUT allows rapid metal melting. Lectromelt makes this possible with large transformers and leads, more efficient cooling and heavier furnace construction.

RAPID TILTING is accomplished smoothly and safely. Mechanism is accurate, strong and side-mounted—located out from under, where it won't get clogged by spillage.

Catalog 10 describes Lectromelt Furnaces. For a copy, write Lectromelt Furnace Division, McGraw-Edison Company, 316 32nd Street, Pittsburgh 30, Pennsylvania.

*Reg. Trademark U.S. Pat. Off.

McGRAW EDISON

Lectromelt

CANADA: Wild-Barfield Electric Furnaces, Ltd., Toronto . . . ITALY: Forni Stein, Genova . . . ENGLAND: G.W.B. Furnaces Limited, Dudley, Worcs. . . . GERMANY: Demag-Elektrometallurgie, GmbH, Duisburg . . . SPAIN: General Electrica Espanola, Bilboa . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Stein & Roubaix, Bressaux-Liege . . . JAPAN: Daido Steel Co., Ltd., Nagoya

STANDARD SIZES UP TO TWO HUNDRED TONS CAPACITY

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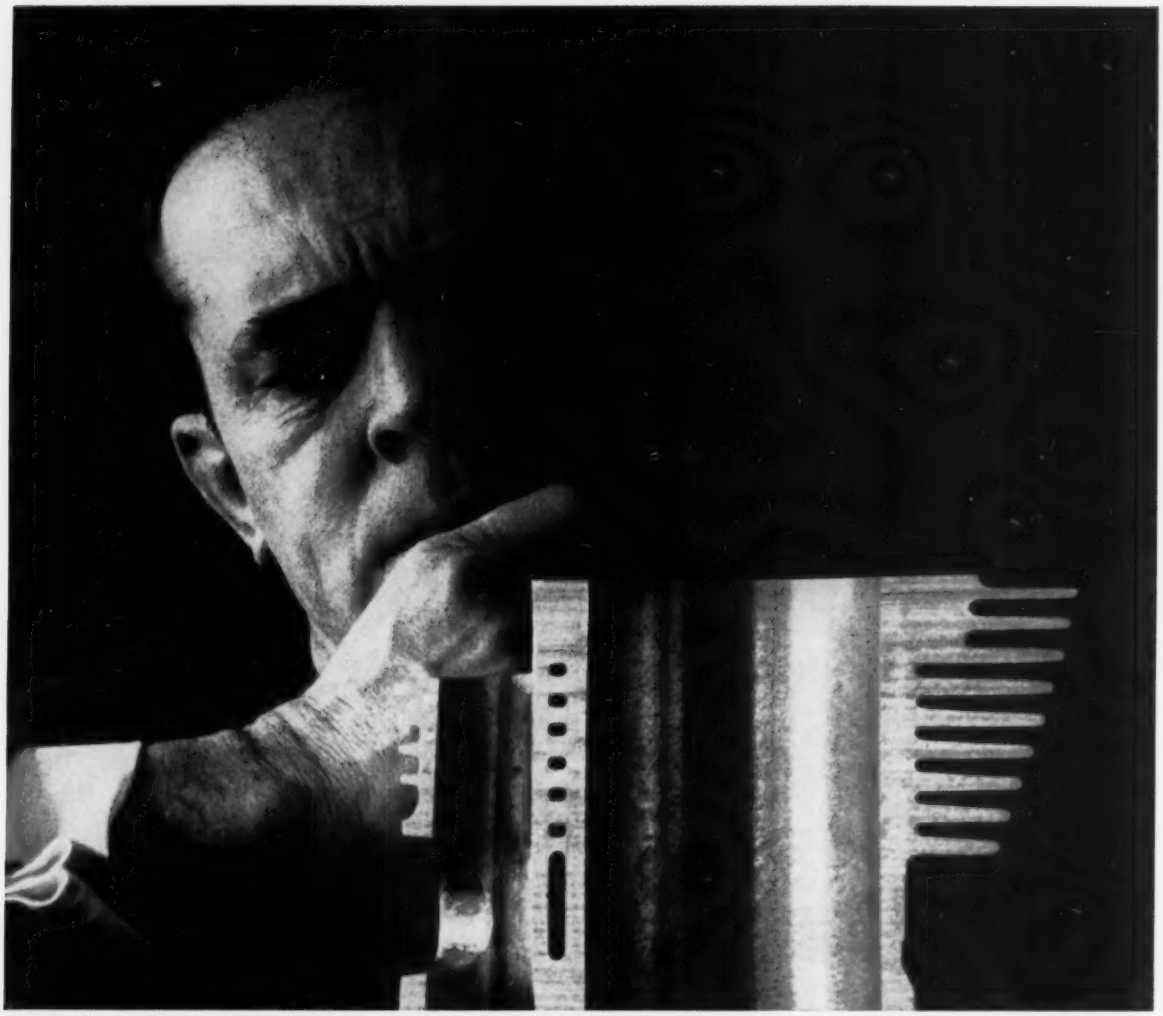


THE PERPLEXING PROBLEM OF HARD SPOTS

Another costly mystery solved–by the man from Kaiser Aluminum

THE PUZZLING FACTS. An aluminum foundryman recently made a disturbing discovery: his castings contained many inclusions and hard spots. These made the castings very unsatisfactory. In addition, they were difficult to machine—and caused excessive wearing of tool bits.

HOW THE CASE WAS SOLVED. It was a frustrating problem. But the man from Kaiser Aluminum found the fault: ineffective fluxing and degassing techniques were being employed. When these were corrected, the hard spots disappeared and production returned to normal.

WE LOVE A MYSTERY. This is one of many actual cases solved by Kaiser Aluminum working with a customer. Perhaps *you* have a mystery one of our technical engineers might help solve? He's ready to give you expert advice on any casting problem—including mold and die design, alloy selection, heat treatment, finishing, fluxing, metal transfer.

FULL ALLOY AVAILABILITIES. Kaiser Aluminum can supply you *fast* with a wide selection of casting alloys to suit any engineering requirement—from general purpose, low stressed alloys to high purity alloys having good properties at elevated temperatures.

FOR PIG AND INGOT with a free sleuthing bonus, call your nearest Kaiser Aluminum sales office now. Or write: Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11, Illinois.

KAISER ALUMINUM

THE BRIGHT STAR OF METALS

See "MAVERICK" • Sunday Evenings, ABC-TV Network • Consult your local TV listing

Circle No. 160, Page 167-168

Diversification of the customer

By W. C. Truckenmiller
Assistant Technical Director
Albion Malleable Iron Co.
Albion, Mich.

The annual cyclic nature of the sale of most manufactured products is a prime factor in the need for customer diversification. Acquisition of customers in preferably widely diverse industries should tend to minimize fluctuations in the demand on the primary producers in our area of interest, the foundries.

Granting the theoretical desirability of such diversification, there are three basic questions which must be thoroughly explored and answered before the inception of major changes. They are: (1) *"What is our present position?"*, (2) *"What is our goal in customer diversification?"*, and (3) *"How do we cover the intervening ground?"*

1 Evaluation of our present position includes such items as a survey of our physical facilities—*current materials, specifications, dimensional capabilities, size, quantity and tonnage limitations, control procedures, and possibilities for appreciable improvement of any of the foregoing at low capital expenditure;* and available manpower (from unskilled labor through management), which should include not only those presently employed but the additional ones available through personnel procurement procedures and training and upgrading programs.

Development facilities, manpower, past accomplishments and immediate prospects must be carefully reviewed. An objective look at current quality, quantity, service, price and competitive position on each of these is most necessary to provide assurance of success.

2 Assuming that the foundry is relatively high production, the following general fields appear open: (1) automotive, (2) truck and trailer, (3) farm implement, (4) road machinery, (5) government, (6) electrical industry, (7) building industry, (8) railroads and (9) own products.

Market surveys are of high value in establishing possibilities in the above fields which may be related to current and prospective capability. New business must come from (1) foundry competitors, (2) conversions from other materials and processes, or (3) new applications.

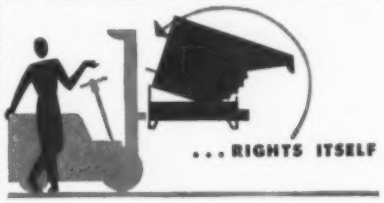
3 Having established current capability and possible new markets, we face the critical problem—"How do we get from here to there?" The rate of advance, or at least change, will be determined in large measure by the maximum safe rate of expenditure. The need for a planned attack is apparent. The sales effort can not be minimized.

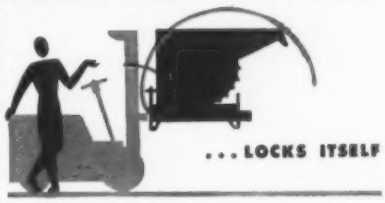
Purchase of a new plant only increases a diversification problem. A sound answer is to develop from within the present organization through initial efforts of a research and development group. What this method lacks in speed, it gains in economy, training of personnel and determination of new capabilities. Close liaison with sales effort is necessary. Many currently successful manufacturing organizations have been built by basic development, laboratory tryout and pilot production before full scale production is attempted. The foundry industry should not ignore this means of approach.

The planned attack of the problem of diversification is necessary to give reasonable assurance of success. Continued development effort in close conjunction with effective sales activity working toward a well-defined market goal will accomplish the desired ends—customer diversification and increased corporate profits.

Editor's Note: This article contains highlights excerpted from a talk presented at the 1958 Purdue Metals Casting Conference.

You'd be surprised how much it cuts operating costs.





How to cut scrap handling costs 50%

Here's the fastest, lowest cost method of scrap handling ever devised. Hundreds of industries are now using Roura Hoppers instead of barrels or tote boxes to collect scrap metal. They're placed alongside machines or in strategic locations. When full, lift truck operator picks up loaded hopper . . . transports it to scrap bin or freight car . . . flips the latch . . . and the hopper automatically dumps its load, rights itself, locks itself. Hopper is returned to its station and operator is free for other work.

Segregation of scrap is simple. Hoppers can be marked for copper, brass, stainless, etc. Brings higher prices.

Roura Hoppers are made in five sizes, ½ to 2 yard capacities. Sturdily built of $\frac{1}{16}$" steel plate with continuous arc-welded seams. Also available in stainless steel or galvanized. Mounted on live skids or a choice of wheels. Standard models available for immediate shipment from stock.

Start cutting costs now . . . with Roura Hoppers. *Remember . . . if it's as good as a Roura it IS a Roura.*

ROURA
Self-Dumping
HOPPER

HERE'S HOW to get more details about Roura Self-Dumping Hoppers. Just attach this coupon to your letterhead . . . sign your name . . . and mail to . . .

ROURA IRON WORKS, INC.
1414 Woodland Ave., Detroit 11, Mich.

Circle No. 161, Page 167-168

let's get personal

Clyde H. Wyman . . . has been appointed manager, Alloy Division, Exomet, Inc., Conneaut, Ohio. He was formerly chief metallurgist, L.F.M. Mfg. Co., Atchison, Kans., and has been in the steel foundry industry for the past 36 years.

D. R. Branaka . . . has been named general sales manager, Sinclair-Collins Valve Co. and Valvair Corp., divisions of International Basic Economy Corp. He succeeds **J. M. Partridge** who has been assigned as manager of Valvair's Cleveland sales office.

D. J. Stearns . . . has accepted appointment to the newly created San Diego sales office representing Ferro Cast (Investment Casting) and the Electronics Div., J. B. Rea Co.

L. D. Richardson . . . has been named assistant vice-president and field sales manager, Eutectic Welding Alloys Corp., Flushing, N.Y. He will assume duties concerning administration and training of technical representatives. Six other men were promoted to the level of field service managers. These men and supervisory areas are: **T. C. Schmidt,** eastern Mich.; **R. E. Saylor,** western Mich. and northern Ohio; **C. E. Kersker,** Va., N.C. and S.C.; **W. S. Wells,** Ga., Ala., Florida and Tenn.; **M. F. Holder,** midwestern states and **Robert O'Gar,** Pacific coast states.

Raymond G. Reiff . . . accepted the position of foundry service manager, American Metallurgical Products Co., Inc., Pittsburgh, Pa.

Albert Musschoot . . . has been appointed director of research and development for Carrier Conveyor Corp., Louisville, Ky. He will be responsible for development of new vibrating equipment.

Dr. Albert Muller . . . has been appointed vice-president of the Air Reduction Sales Co.—the industrial gases and welding products division, Air Reduction Co., New York. He was formerly director of metallurgical research for the firm's Central Research Laboratories.

E. A. Axelson . . . has joined the sales staff of Refractories Div., H. K. Porter Co., Inc., Pittsburgh, Pa. Axelson will work initially with steel mills on pouring-pit refractories and will be active in Porter's basic-refractories applications for furnace construction. **W. D. Fullerton** has been appointed assistant general manager and **W. L. Fabianic** named director of research.

Roger B. Sinclair . . . has formed Roger B. Sinclair Associates, foundry management consultants, Larchmont, N.Y. Sinclair was formerly head of the Meehanite Metal Corp. management engineering division.

James P. Spresser . . . formerly of Schenectady, N.Y., has been appointed manager-planning, standards and methods of the Everett foundries of General Electric's foundry department. **Bernard J. Alperin,** also formerly of Schenectady, has been named supervisor-inspector of the Everett foundries.

Richard L. Gutenkunst and **Thomas J. Gutenkunst** . . . have been elected vice-presidents of Milwaukee Malleable & Grey Iron Works.

Hans G. Hinrichs . . . has been appointed sales engineer, Herman Pneumatic Machine Co., Pittsburgh, Pa.

Leslie F. Schurck . . . is now director, industrial engineering, Cooper Alloy Corp., Hillside, N.J. **Ramon J. Galvez, Jr.,** has been named as radiology supervisor, Cooper Alloy Corp.

H. G. Seamans . . . formerly with Bremen Grey Iron Foundry, Bremen, Ind., is now with Peru Foundry, Peru, Ind. He is a member, AFS Michiana Chapter.

Ralph G. Dermott . . . formerly project engineer, American Brake Shoe Co., Mahwah, N.J., is now assistant research metallurgist, Bridgeport Brass Co., Havens Research Laboratory, Bridgeport, Conn. He is a member, AFS Connecticut Chapter.

William M. Ewing . . . has been appointed vice president and general manager, National Malleable & Steel Castings Co., Capitol Foundry Div., Phoenix, Ariz., succeeding **E. A. Spring,** who will continue as a consultant. Other changes in operating executives at National Malleable & Steel Castings Co. include: **L. G. Blackmon,** general superintendent of Sharon Works becomes manager; **K. L. Selby,** vice-president, Transportation Products Division, has been appointed vice president and general manager of the division.

R. W. Patridge . . . has been appointed as sales manager, Special Products Division of Lebanon Steel Foundry, Lebanon, Pa. **D. F. Smith** has been named sales engineer in charge of atomic energy work.

R. G. Heckenkamp . . . has been appointed assistant secretary-treasurer, Carondelet Foundry Co., St. Louis. He has been with the company since 1950.

R. D. Everett . . . is general superintendent, Sharon, Pa., Works of National Malleable & Steel Castings Co. **Louis Englebaugh** has been made general superintendent of the company's Melrose Park Works.

Leonard Hauber . . . is foundry superintendent of H. C. Weiskitell Co., Baltimore, Md. He was formerly with Fletcher Works, Inc., Philadelphia.

Paul Rader . . . is plant manager, Burnham Corp., Lancaster, Pa. Other appointments are: **Joseph Madden,** foundry superintendent; **Robert Husson,** general foreman; **David Keener,** personnel manager.

M. J. O'Brien, Jr. . . . formerly manager of manufacturing, Everett & Lynn Foundries, General Electric Co., is now manager for steel foundry expansion, General Electric Co., Schenectady, N. Y. He served as an AFS National Director, 1951-1954.

W. H. Baer . . . formerly Bureau of Ships, Navy Department, Washington, D. C., is now with the Dept. of Army, Engineering Research Development, Fort Belvoir, Va.

F. M. Egan . . . is assistant procurement manager, Crouse-Hinds Co., Syracuse, N. Y. He joined Crouse-Hinds in 1947.

James Mitchell . . . is now district sales manager in Colorado area for Harbison-Walker Refractories Co. He was formerly in the Philadelphia district.

R. J. Laws . . . will fill the position as general manager, Baker Industrial Trucks Div., Otis Elevator Co., Cleveland.

T. S. Hartzell . . . is the president of a new commercial zinc and aluminum die-casting company named Hartzell Manufacturing, Inc., St. Paul, Minn. Other key personnel are: **J. R. Hartzell,** secretary; **J. T. Walker,** executive vice-

Continued on page 28

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STANDARD FERROMANGANESE • MEDIUM CARBON FERROMANGANESE • SILICOMANGANESE • EXOTHERMIC FERROMANGANESE
MANGANESE BRIQUETS • SILICOMANGANESE BRIQUETS • 2" x 8 MESH • 2" x ¼" • 8 MESH x DOWN • 75= x 2"
Mn 25
Manganese
54.94
CRYSTAL
a β γ
SHELLS
N 2
M 13
L 8
K 2

Manganese, an element essential in cast iron, is available to the foundry industry in a number of ferro-alloys.

No single manganese alloy is right for all irons and melting conditions. Rather, specific manganese alloys and sizings have been developed which provide maximum economy and effectiveness for specific applications.

OUR BROCHURE, "MANGANESE IN CAST IRON," discusses the function of manganese in iron and will serve as a guide to the proper manganese alloy for your cupola or ladle needs.

Write for your copy or contact our nearest sales office.

QUALITY SERVICE DEPENDABILITY

Ohio Ferro-Alloys Corporation
Canton, Ohio

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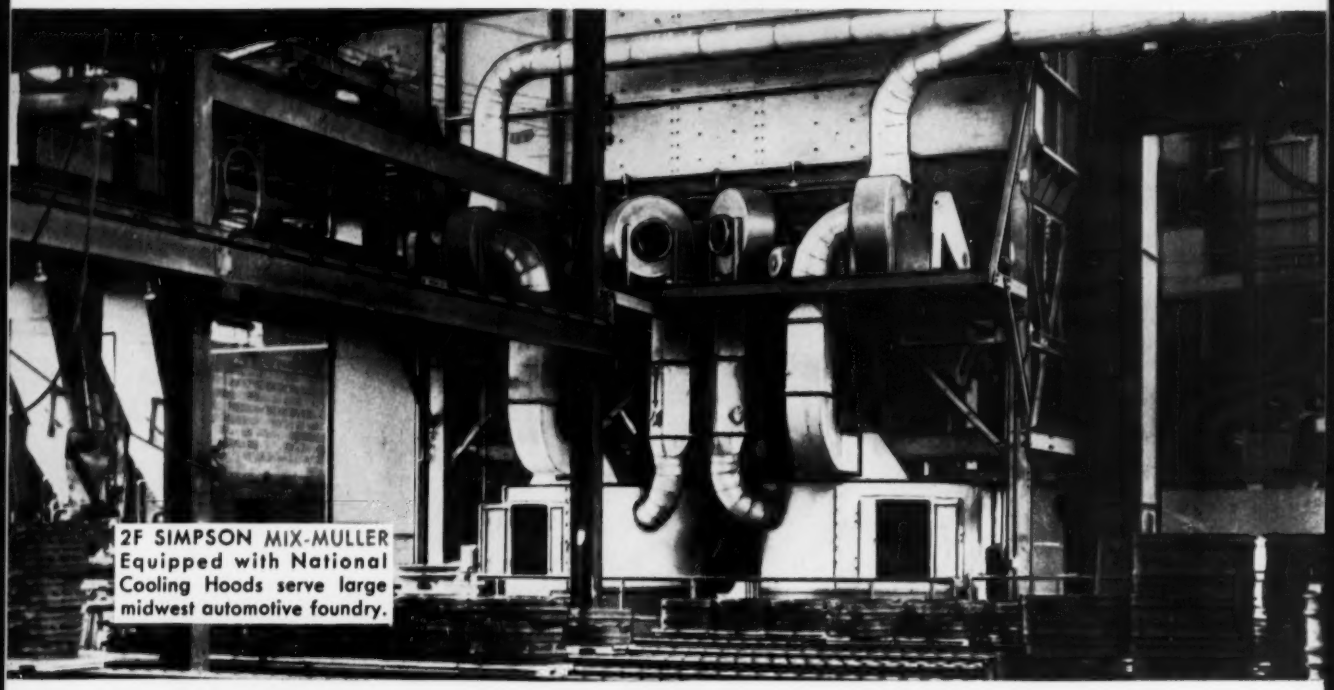
—IF YOU HAVE A



2F SIMPSON MIX-MULLER Equipped with National Cooling Hoods serve large midwest automotive foundry.

. . .These simple facts may save you money

Foundrymen agree that the best place to deal with a serious hot sand problem is after shakeout and *before* storage or rebonding. But what do you do if pre-cooling is physically or economically impractical?

Can you cool in the Muller?

Depends upon the muller. Sands in the marginal temperature range (150°—175°) can often be reduced to within 20° of room temperature in a Simpson Mix-Muller during a normal mulling cycle, *without the need of extra cooling equipment.*

This is possible because the Simpson Mixer operates at an optimum speed necessary to thoroughly temper the sand. This action serves as a most efficient cooling medium and is described in cut (A). A simple way to determine whether or not *your* muller delivers this cooling action is to check the temperature of the sand before and *after* it has been mulled.

Cooling Hoods

Where temperatures range above 250° as sand comes to the muller, cooling usually must be induced by mechanical means in the muller. Here again, the cautious foundryman should judge equipment by personal inspection. He should ask for evidence that cooling equipment does not impair the quality and productivity of the mixing operation by calling for excessive binder additions and reduced batch size. A check of power costs is also important.

The National Cooling Hood

If you now operate a Simpson Mix-Muller or intend to purchase a mixer equipped for cooling, it will pay you to evaluate the practical design and operating characteristics of the National Hood shown here . . . *then prove them for yourself.*

You can do so by sending for a complete list of National Cooling Hoods built since 1950. Your National agent will be glad to arrange a demonstration of why and how the National Hood can effectively solve your hot sand problems at low first and operating costs . . . *without impairment to your mixing productivity or to the quality of the prepared sand.*

Write for further details today or call your *Man from National.*

.....NATIONAL ENGINEERING COMPANY.....

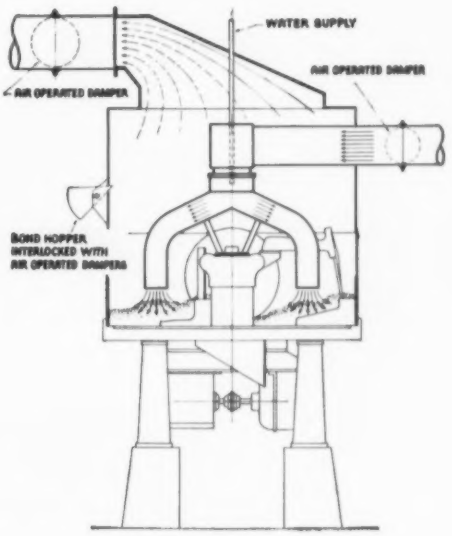
HOT SAND PROBLEM

THE NATIONAL ROTARY PUSH-PULL COOLING HOOD

Here's how it works:

Moisture is added and air is forced *through* the batch while sand is in a state of normal agitation (and maximum flowability) due to plow action. As moisture is evaporated, heat in sand is transferred to the vapor generated and is carried off in exhaust system. Slight negative pressure is maintained in mixer to confine dust within the mixer enclosure.

PLOW ACTION *holds key to effective cooling:* (see A, below) note that air is directed through sand as it cascades over the plow in a free flowing state . . . rather than from *below*—where higher air velocity would be required to overcome natural compaction of sand.

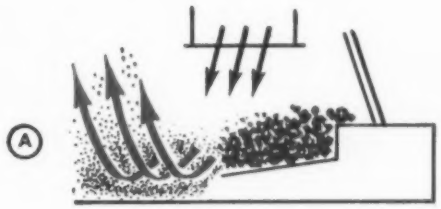


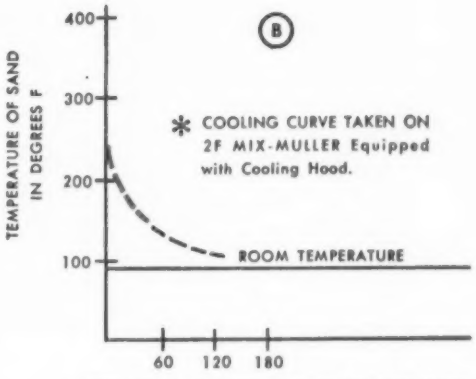
HERE'S WHAT IT WILL DO FOR YOU

The National Cooling Hood will reduce sand temperature from 250° to within 15 to 20° of nominal (90°—100°F) room temperature during a normal 2 minute mulling cycle. In addition, you get:

- **no loss to fines** . . . because excessive air velocity is not required. 6500 CFM is used (other systems require up to 11,000 CFM for a mixer of *smaller* batch capacity).
- **no adjustment to normal batch composition** is required to compensate for excessive moisture or loss of binders and additives through the exhaust system.
- **no loss in quality** of prepared sand.
- **no loss in productivity** or speed of preparation. Mix-Muller operates on same cycle, with or without a cooling hood.
- **no excessive power costs.** Mix-Muller uses same HP motor, with or without cooling hood.

These benefits add up to low cost and efficient sand cooling without physical or economical penalty being placed on your sand preparation operations . . . when you choose the *practical* MIX-MULLER/NATIONAL way.





*Name of foundry will be supplied upon request.

F-159

. . . . 630 Machinery Hall Bldg. • Chicago 6, Illinois. . .

PRODUCTS OF THE PRACTICAL FOUNDRYMAN

Circle No. 163, Page 167-168

Your dependable source of supply for...

EASTERN CLAY PRODUCTS

Nothing better at any price

Eastern Clay Products produce, and Hickman, Williams & Company sell and distribute these well-known brands:—Cupoline; Dixie Bond; Revivo Bond; Plasti-Bond; Black Hills Bentonite; Lawco Fire Clay—all to make castings better and reduce chances of molding failures.

Eastern Clay Products is a department of International Minerals & Chemical Corporation, whose staff of engineers are available (gratis).

International MINERALS CHEMICALS

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Hickman, Williams & Co.

CHICAGO • DETROIT • CINCINNATI • ST. LOUIS • NEW YORK
CLEVELAND • PHILADELPHIA • PITTSBURGH • INDIANAPOLIS
Established 1890

Circle No. 164, Page 167-168

let's get personal

Continued from page 24

president and general manager; **M. J. Laub,** vice-president and director of sales; **Paul Schaeppi,** comptroller; **D. L. Brink,** industrial engineer; **William Reich, Jr.,** tool-room superintendent and **Ednor Kohn,** die-cast supervisor.

R. N. Janeway . . . has been appointed vice-president, engineering, of Consolidated Foundries & Mfg. Corp., Chicago. He will direct a new corporate development program and will continue to head his own engineering firm, Janeway Engineering Co., Detroit.

T. H. Reidy . . . has joined the staff of Lester B. Knight & Associates, Inc., Chicago, as vice-president. Reidy was formerly chairman of Skymotive, Inc.

E. A. Loria . . . is the new development manager, high temperature and corrosion resistant alleys, Climax Molybdenum Co., a division of American Metal Climax, Inc., New York. Loria's headquarters will be the firm's Pittsburgh office.

P. E. Giberson, Jr. . . . formerly with National Foundry Sand Co., Houston, Texas, is now vice-president, Guy-Berson Sand Co., Houston, Texas. He is a member of the Texas Chapter.

Earl Beyerlein . . . formerly with Eaton Mfg. Co., Vassar, Mich., is now with Fuller Mfg. Co., Kalamazoo, Mich. He is a member of the Central Michigan Chapter.

J. D. Dibble . . . formerly with Patton Mfg. Co., Marietta, Ohio, is now with Frazer & Jones Co., Syracuse, N. Y. He is a member of the Central New York Chapter.

John N. Ludwig, Jr. . . . has been appointed supervisor, metallurgical services, International Nickel Co., with headquarters in Pittsburgh, Pa.

George H. Schippereit . . . is now technical adviser, Battelle Memorial Institute, Columbus, Ohio. He assumes responsibility for advising the Institute's metallurgical sponsors on formation of their research programs.

J. Harry Reed . . . formerly sales manager, is now vice-president, sales, Youngstown Foundry & Machine Co., Youngstown, Ohio.

Savin Zavarella . . . president, Pressure Blast Mfg. Co., Manchester, Conn., is now also general sales manager.

Harrison Taylor . . . former assistant district manager of the New York district office of Whiting Corp., Harvey, Ill., has been named as manager, St. Louis office succeeding the retired Frank P. Walsh.

Circle No. 210, Page 167-168

Good news! Now foundries can *really* cut steel abrasive cleaning costs — by discontinuing the use of high priced steel abrasives and changing to "SEMI-STEEL" shot and grit — saving $50 or more per ton before opening a bag!

"SEMI-STEEL" is not just low cost shot and grit. Rather, it's an entirely *new* type steel abrasive, produced by a *new* process so economically that it can be sold at this extremely low price. It does an excellent cleaning job — and does it faster than the best steel abrasive. Furthermore, "SEMI-STEEL" has proved easier on equipment than steel abrasives, so you save money on maintenance costs, too.

We're so confident that "SEMI-STEEL" will reduce your cleaning costs that we'll give you a *written guarantee* to that effect. Please order "SEMI-STEEL" on that basis at any time. Also, inquire about our free engineering service and laboratory tests — and ask about our lower prices on malleable and chilled abrasives.

METAL BLAST, INC.

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ALSO IN: Chattanooga • Chicago • Cincinnati • Dayton • Detroit • Elberton, Ga. • Grand Rapids • Greensboro, N. C. Houston • Los Angeles • Louisville • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh and St. Louis.

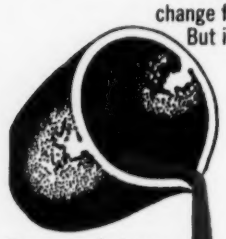
BOY! was my face RED!

I'd always used crucible furnaces in my shop, until a few years ago. Then, I switched.

But not for long!
I'm back to
crucible furnaces again.
Why? two counts:
Cost, and **flexibility.**

Know what I found? My crucible cost, per pound of metal melted is **no higher** today than it was in 1940! Sure, crucibles cost a little more today, but I get more heats. I checked my old records, and per pound of metal melted my **crucible costs are the same!** And another thing — **flexibility.** On a lot of these non-crucible furnaces, try and change from one metal to another without contamination! But in my crucible furnaces, I just change from one crucible to another, fast, simple, and trouble free!

From now on, its **crucible melting** for me!



These manufacturers are ready to assist you with melting and pouring problems, foundry layouts and crucible furnace servicing.

AMERICAN REFRACTORIES & CRUCIBLE CORPORATION
JOSEPH DIXON CRUCIBLE CO.
ELECTRO REFRACTORIES & ABRASIVES COMPANY
LAVA CRUCIBLE-REFRACTORIES COMPANY
ROSS-TACONY CRUCIBLE CO.
VESUVIUS CRUCIBLE COMPANY

Crucible Manufacturers' Association

CRUCIBLE MANUFACTURERS ASSN.

☐ Send "Crucible Charlie" Brochure #3 "Furnace Maintenance".
☐ Send "Crucible Charlie" Brochure #4 "Proper Fitting Hardware".

NAME.....
POSITION.....COMPANY.....
ADDRESS.....
CITY.....STATE.....

Circle No. 165, Page 167-168

obituaries

Norman F. Hindle, 57, Professor and Head of the Mechanical Engineering Dept., University of Idaho, Moscow, Idaho, and AFS Staff member from 1933 to 1946, died in March.

Following his graduation from Purdue University in 1925, he joined American Steel Foundries, first as a laboratory assistant at the Alliance, Ohio plant, then as chief chemist at the Indiana Harbor, Ind., plant. From 1928 to 1931 he was an assistant editor of *Foundry* magazine, leaving to return to American Steel Foundries.

He joined the American Foundrymen's Society in 1933 as a staff assistant, serving as Assistant Technical Assistant 1936-1944 and Director of the newly formed Technical Development Program 1944-1946. He was instrumental in the developing of many AFS publications and was active in encouraging foundry educational work.

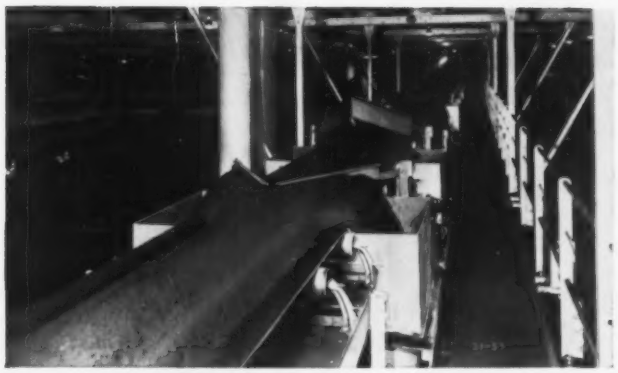
Hindle, after leaving the Society, joined the staff at the University of Idaho. In 1958 he received an award from the American Society of Mechanical Engineers for work done on the local chapter level.

Richard E. Hayden, 51, sales manager, Fuel Fired Furnace Div., Hevi-Duty Electric Co., Milwaukee, died March 5. He was sales manager, Industrial Furnace Div., Eclipse Fuel Engineering Co., prior to purchase of that division by Hevi-Duty Electric Co. in July, 1958.

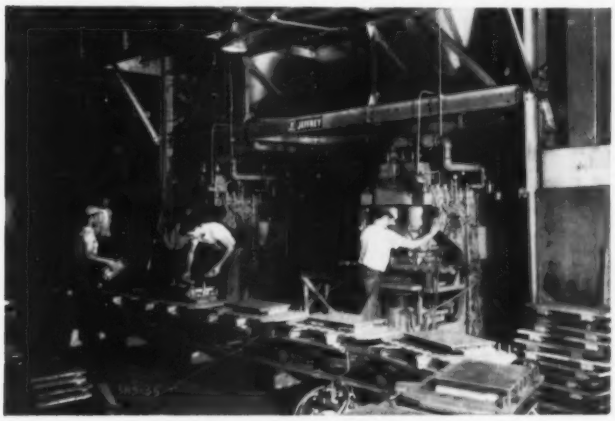
Earl Paltenghi, vice-president and general manager, H. C. Macaulay Foundry Co., Berkeley, Calif., died March 8 after a short illness.

He had served with Macaulay Foundry Co. for more than 20 years. Paltenghi was active in foundry industry activities and was serving as a director of the AFS Northern California Chapter and chairman of its finance committee. In addition he was a director of the Gray Iron Founders' Society and a past trustee of the Foundry Educational Foundation.

C. B. Tebbetts, president and sales manager, Los Angeles Steel Casting Co., Huntington Park, Calif., died recently.



Jeffrey Sand Handling Belt Conveyor with Automatic Plows



Jeffrey Universal Mold Conveyor

Jeffrey Universal Mold Conveyor, Automatic Mold Dumper and Apron Conveyor

Jeffrey Apron Conveyor Handling Castings

you'll see the difference in foundries planned by JEFFREY

MECHANIZATION takes over many operations formerly requiring manpower—from sand preparation and distribution to the molders and core makers, to the pouring positions and shakeouts, then back to sand reclaiming and storage—moving raw materials and processing finished castings. Jeffrey services to the foundry industry are that complete.

We'll start with a survey, prepare layouts and recommend equipment, build and install a system to suit your exact requirements. We'll alter existing facilities or replace obsolete units with modern, efficient Jeffrey machinery.

Catalog 911 describes these services and equipment. For a copy, write to The Jeffrey Manufacturing Company, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT
TRANSMISSION MACHINERY • CONTRACT MANUFACTURING

Circle No. 166, Page 167-168

H-25 PAYLOADER®

"moves 25-30% more material"

Bremen Gray Iron Foundry, Inc., Bremen, Ind., has been using "PAYLOADER" tractor-shovels for 9 years and has developed an efficient "PAYLOADER" sand-handling set-up.

According to General Manager, H. J. Hueni, their Model H-25 with 1,500 hours of service is an 11 to 16-hour work horse each night. It moves the castings and sand (about 250 tons) from the floor to the shake-out about 200 feet distant. On return trips, it delivers sand (about 210 tons) from muller to the 35 molding stations.

Night Foreman, Gene Hawkins says, "No getting around it, our 'PAYLOADER' units do lots of work and require few repairs. The Model H-25 has greatly improved material-moving efficiency. Its larger capacity, combined with power-shift transmission and power-steer, are the main reasons it moves 25 to 30% more tonnage an hour than our Model HA's."

More power—more traction
Backing up the increased carry capacity (2,500 lbs.) and faster cycles of the Model H-25 are greater engine power, power-transfer differential and 4,500 lbs. of bucket breakout force that provide more reliable traction and digging power . . . all accomplished while reducing the turning radius to 6 feet.

If you want the most carry capacity on the shortest-turning tractor-shovel for sustained high output, ask your Hough Distributor to demonstrate a Model H-25.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

THE FRANK G. HOUGH CO.
711 Sunnyside Ave.
Libertyville, Ill.

Send complete data on the Model H-25 "PAYLOADER"

5-A-2

Name
Title
Company
Street
City State

Circle No. 167, Page 167-168

pouring off the heat

march meets approval

■ Having spent last evening thoroughly digesting your most excellent March issue, I am now anxious to obtain a number of copies of Jules Henry's paper, *"Aid for the Design Engineer"*. We are conducting a series of in-plant seminars with our ductile iron customers and find the reference paper most attractive.

G. W. PHELPS
Otaco Ltd.
Orillia, Ont.

■ The March issue of MODERN CASTINGS arrived yesterday. Let me tell you that, in my opinion, it is about the finest issue that I have had the privilege of seeing. It does seem to me that there is a need for the type of articles that appear in this issue. Again, sirs, my profound congratulations.

GILBERT S. SCHALLER
Department of Mechanical Engineering
University of Washington
Seattle

Jamaica iron?

■ Along the north coast of Jamaica in the town of Falmouth I came upon this structure which I photographed for you. It is supposed to be the first

iron foundry in this part of the world and is more than 300 years old. It is now used for storing rum and sugar cane.

O. JAY MYERS
Reichhold Chemicals, Inc.
White Plains, N.Y.

hands across the sea

■ We are very much obliged for your close cooperation in conducting a visit to your society for the members of our Small Foundry Management

Continued on page 37

Angling for Cleaner Iron?

try *Famous* CORNELL CUPOLA FLUX

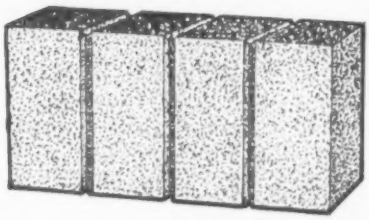
for GRAY IRON and MALLEABLE FOUNDRIES

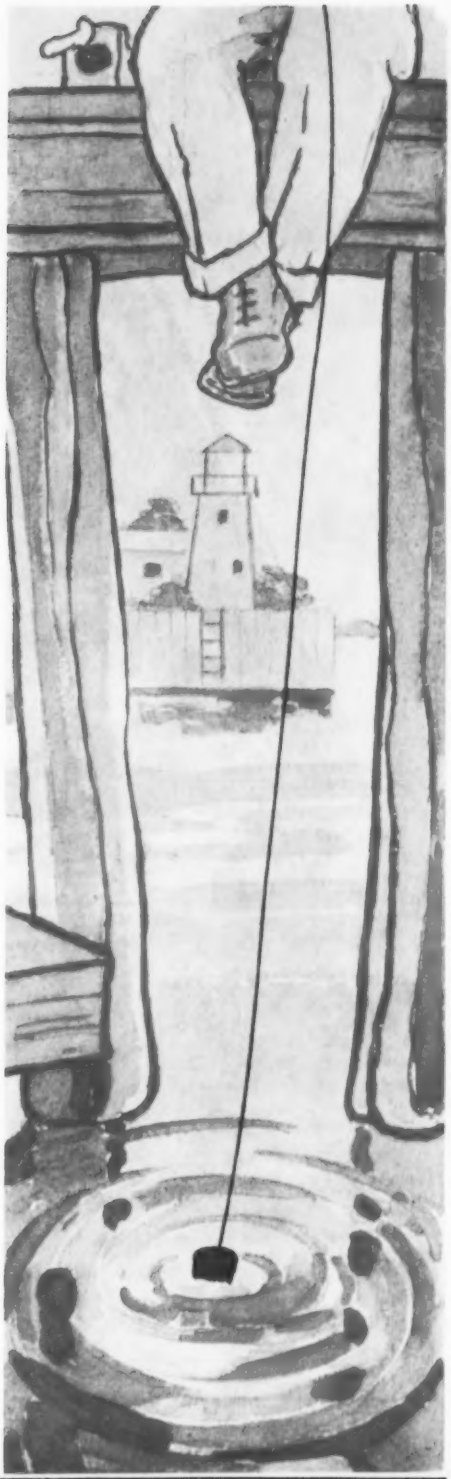
You produce cleaner castings and cut rejects to a minimum. That's why so many foundries make it "standard operating procedure" to use Famous Cornell Cupola Flux. By constant use of this scientifically-designed mixture of high-grade fluorspar and other materials you get these advantages: increase in the amount of slag that floats and flows off, sulphur greatly reduced, cleaner castings and rejects cut to a minimum.

Why not call us today or send for Bulletin 46-B.

Have you tried Famous Cornell Aluminum, Copper or Brass Flux? Write for Bulletin 46-A.

don't accept substitutes





The CLEVELAND FLUX Company

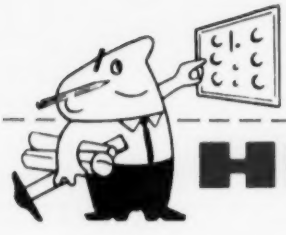
1026-40 MAIN AVENUE, N. W. • CLEVELAND 13, OHIO

Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes—Since 1918

FAMOUS CORNELL FLUXES

Trade Mark Registered

Circle No. 168, Page 167-168



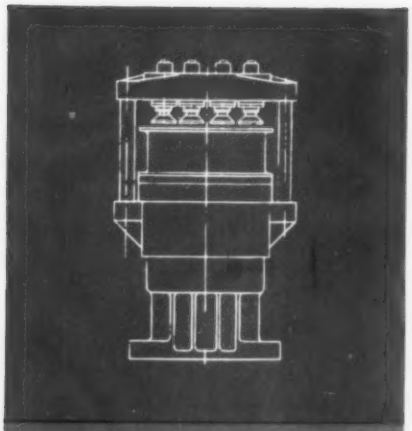
HERMAN

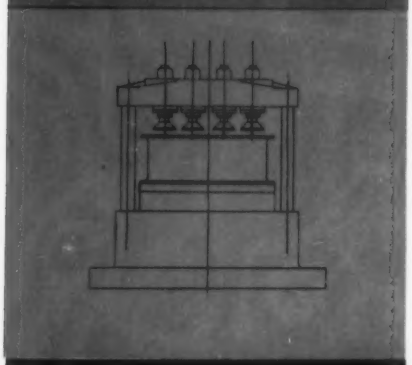
FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION INC. MEMBER FEMA

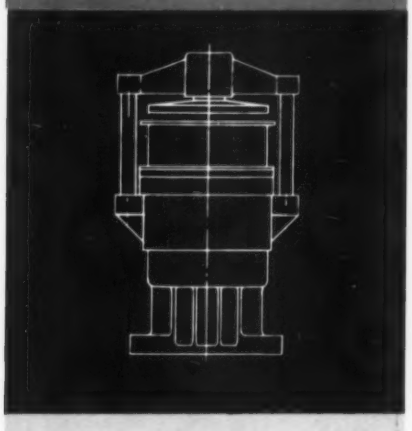
and most progressive

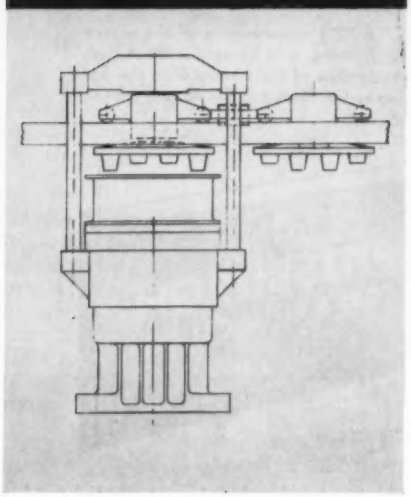
Best Known Name in Engineered Molding Machines

Circle No. 169, Page 167-168









a type and size molding machine for every foundry operation . . . .

A long-standing, progressive policy here at the Herman Company has resulted in the continuous development of new and better molding machines.

Our complete line now includes *15 different types* to meet the demands of modern foundry operations.

One outstanding end product stemming from our drawing boards is the MOLDMASTER.

This revolutionary Herman machine was designed to meet the normal molding requirements of most foundries.

The Moldmaster, a jolt, squeeze, strip machine, operates by automatic, semi-automatic or push-button controls.

It offers pattern contour mold compacting which results in maximum versatility for all types of molding.

A self-adjusting squeeze head attached to the jolt machine, table flows the sand in such a manner that perfect molds are insured. The machine accommodates itself readily to four different molding methods, depending on your requirements.

The Moldmaster typifies our research into better ways to build better molding machines to better the industry.

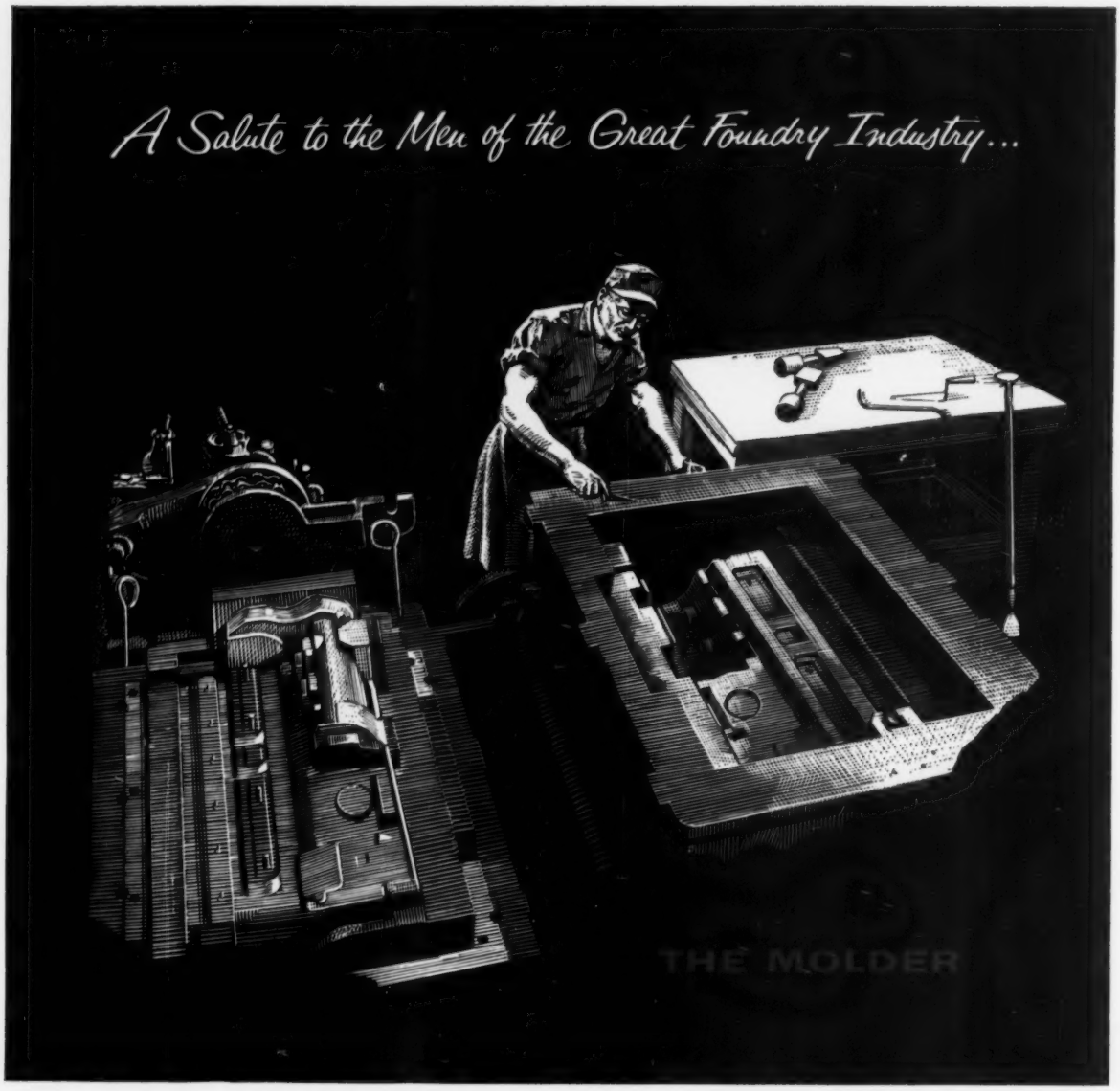
We have detailed literature available on the Moldmaster, as well as the complete Herman line. Yours for the asking.

HERMAN PNEUMATIC MACHINE CO.

UNION BANK BUILDING, PITTSBURGH 22, PA.

Circle No. 169, Page 167-168

A Salute to the Men of the Great Foundry Industry...



MOLD-MAKING is a key operation in the foundry industry. Although modern foundry practices have done much to mechanize the production of molds, the work of the hand molder is still a vital ingredient in the production of many castings.

His skill in hand-tamping the mold and in dressing it to final, accurate form is largely responsible for the high quality of castings produced by America's foundries.

Pittsburgh Coke & Chemical is proud to salute the gray iron foundry Molder. It is equally proud to serve as a basic supplier of two quality products for the nation's foundry trade . . . NEVILLE PIG IRON and NEVILLE FOUNDRY COKE.

An enlarged (11½" x 12") reproduction of the above etching, suitable for framing, will be sent without cost, upon request. Reproductions of the etching from the first advertisement of this series, featuring the Pattern Maker, are also available.

WSW 7415

PITTSBURGH COKE & CHEMICAL CO.

Neville Pig Iron and Neville Coke for the Foundry Trade

PIG IRON • COKE • FERROMANGANESE • CEMENT • COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON

Circle No. 170, Page 167-168

Pouring off the heat

Continued from page 32

Study Team. We are sure that your kindness will remain in our hearts and bring about good understanding and friendship, and that your suggestions about foundry management and techniques will stimulate further development of the iron casting industry in Japan.

JINICHI TAKEYAMA
Takeyama Foundry Works, Ltd.
Nakagawa-ku, Nagoyashi
Japan

■ I am indebted to you for the courtesy of extending your helping hand to me in securing employment in the U. S. Your gesture of international friendship has been appreciated both by me and my friends. I hope that such a sincere effort in helping me to build my career is going to be fruitful.

TARWINDER SINGH SARNA
Ordnance Factory
Murad Nazar
India

furnace needed

■ The AFS Metropolitan Chapter would like to acquire a melting furnace of approximately 50 to 100-lb capacity to present as a gift to the AFS Student Chapter at the Polytechnic Institute of Brooklyn. The furnace is to be for student use in melting cast iron and steel. Its capacity is not too significant. It is to be used for instructional purpose, melting a charge at a time.

I am writing to reach someone who might have melting equipment suitable for this purpose who might be willing to donate it or sell it at a nominal price for education purposes.

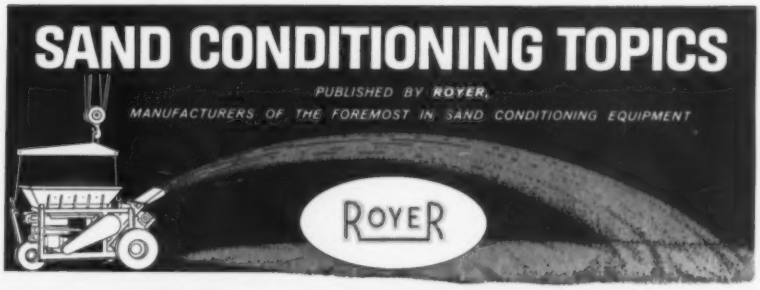
WILLIAM T. BOURKE
Chairman, Metropolitan Chapter
c/o American Brake Shoe Co.
Mahwah, N.J.

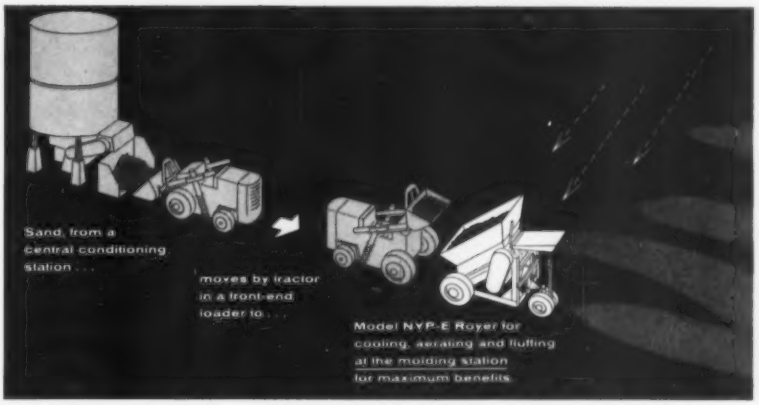
Here's your chance to help a worthy cause. Contact William Bourke if you have a furnace suited to his need. —Editor

size meets approval

■ Several years ago when you increased the size of your magazine I wrote and suggested that you should go back to the regular magazine size. I note that you have now gone back to the regular magazine size and am writing to commend you for this change.

WALKER REYNOLDS
Alabama Pipe Co.
Anniston, Ala.




Sand, from a central conditioning station . . .
moves by tractor in a front-end loader to . . .
Model NYP-E Royer for cooling, aerating and fluffing at the molding station for maximum benefits.

THERE IS A SAND CONDITIONING SYSTEM TO FIT YOUR BUDGET . . .

Here is a positive cost-cutting sand conditioning system that falls within the budget limitations of the small or medium semi-mechanized foundry. It delivers better sand without adding to time or manpower requirements, and without the expense of complete mechanization. It gains the advantages of fluffing after handling, as the final step at the molding station.

Teamed with front-end loader, this Royer NYP-E Portable moves from floor to floor in this grey iron foundry. What used to be caked, packed sand from mulling is now a cool, fluffy pile.

An integral part of this practical system is the Royer Model NYP-E Sand Separator and Blender. It can be moved swiftly from station to station, delivering cooled, aerated, fluffed, perfectly conditioned sand right where it's wanted. With this Royer you can really get all the advantages of central system sand control.

Your system is probably "different." There's still a versatile unit of the Royer "NY" Series to fit it . . . and improve it. As a stationary model, the "NY" will fit into a conveyor system, or can be installed to take the discharge of stiff sand directly from your muller. However you use it, the Royer vastly improves sand, saves time and money, improves yield and quality of castings —all at a fraction of a cent per ton of sand.

We'll be happy to have an experienced, foundry-wise Royer agent call to help you work out the system that's best for your operation. Or, if you prefer, we'll rush you a copy of Bulletin NY-54, giving further information about these units and how you will benefit from them. When you're convinced, *you* can call in your Royer agent and take the first step towards better sand with a Royer system.

ROYER FOUNDRY & MACHINE CO.

ROYER 155 PRINGLE STREET KINGSTON, PENNA.

☐ Tell your agent to call.
☐ Rush me a copy of Bulletin NY-54.

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

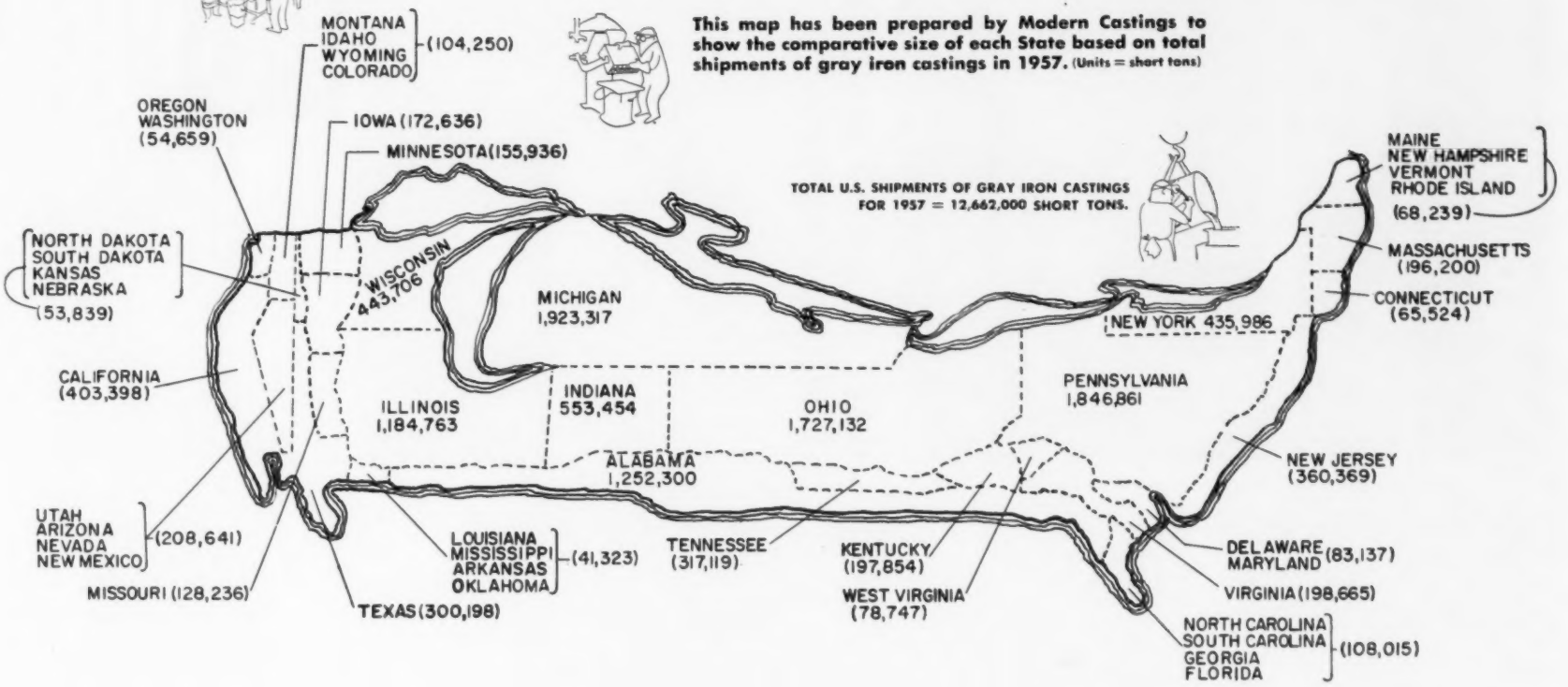
Circle No. 171, Page 167-168

how's business . . .

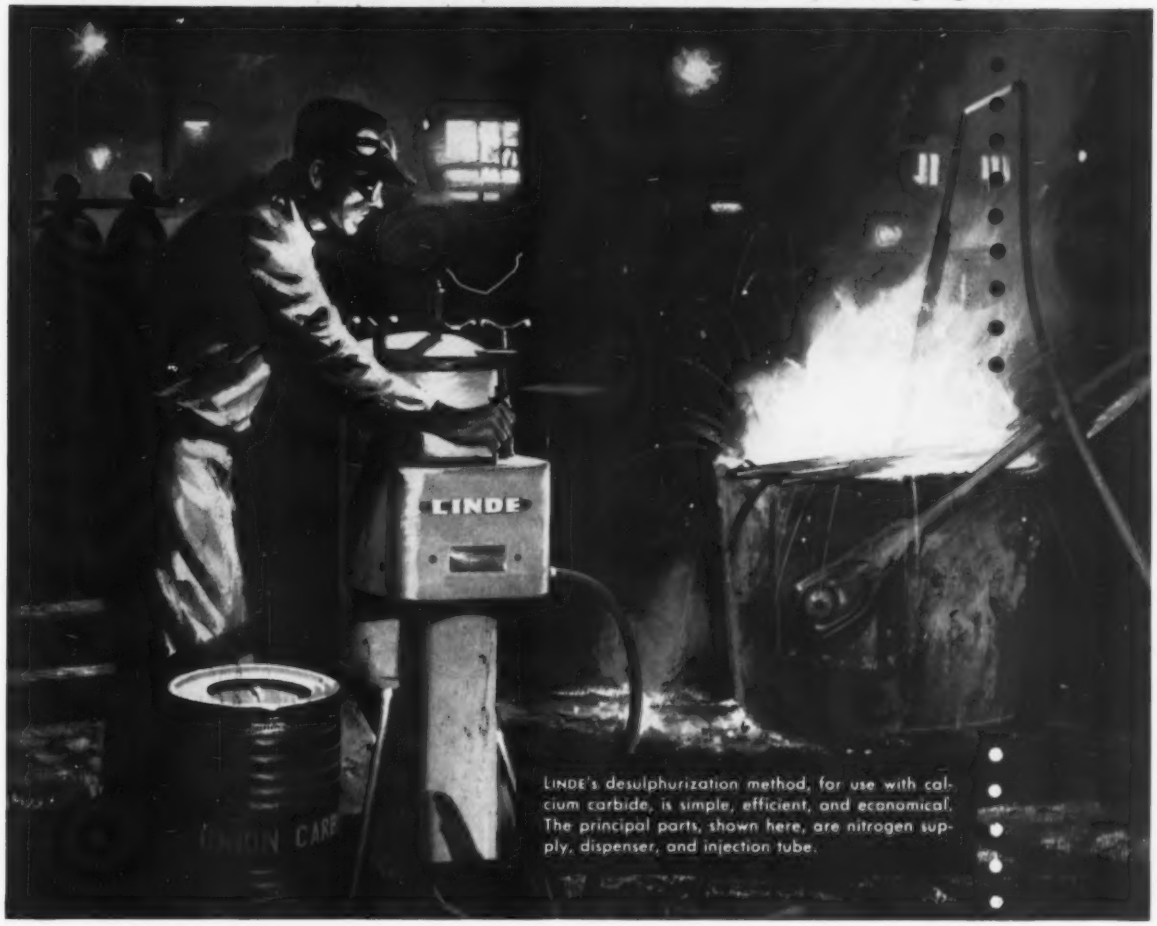
How the United States Looks to the Gray Iron Industry

This map has been prepared by Modern Castings to show the comparative size of each State based on total shipments of gray iron castings in 1957. (Units = short tons)

TOTAL U.S. SHIPMENTS OF GRAY IRON CASTINGS FOR 1957 = 12,662,000 SHORT TONS.



DESULPHURIZATION...



LINDE's desulphurization method, for use with calcium carbide, is simple, efficient, and economical. The principal parts, shown here, are nitrogen supply, dispenser, and injection tube.

You get uniform results with Metallurgical Carbide from LINDE

In the foundry, you can produce high grade iron only by making sure you use metal with a low sulphur content. As a desulphurizing agent, metallurgical calcium carbide assures *uniformity* in the metal you produce. You know in advance that by adding a certain amount of carbide you remove a certain percentage of sulphur. Because metal specifications can be met efficiently and economically with carbide, you eliminate any need for wasteful "trial and error" methods.

Linde's method of mixing UNION calcium carbide and molten iron is simple and sure. A stream of fine mesh carbide and nitrogen under pressure is forced from a dispenser through a hose. The graphite injection tube is immersed deep in the hot metal. The carbide blends evenly and thoroughly with the iron. Desulphurization with UNION calcium carbide creates no fumes, does not attack refractories. The LINDE equipment—nitrogen supply, dispenser, and injection tube—is easy to operate and maintain.

If you would like more information about LINDE's method of desulphurization, using calcium carbide, just call or write your nearest LINDE office. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE MARK

UNION CARBIDE

The terms "Linde," "Union" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle No. 172, Page 167-168

Report on the

63d AFS CASTINGS CONGRESS

Technical Papers • • • Awards • • • Seminars • • • Elections

Chicago became the focal point of the metalcasting industry with over 4817 foundrymen, casting buyers and design engineers on hand to participate in the 63d Castings Congress & Engineered Castings Show, April 13-17.

Modern casting technology was advanced a bold step into the future by some 95 technical papers prepared by the top men in the field. Congress papers covered such diverse areas of importance as . . . production of gray iron directly from iron ore . . . casting heavy section malleable iron . . . new resins for shell molds and cores . . . use of light metal castings by aircraft designers . . . vacuum die casting . . . managing profit through cost control . . . casting problems . . . high strength steel castings.

AFS President Lewis H. Durdin stated in the President's Annual Address at the annual business meeting that . . . AFS now has 12,519 members, 47 regular chapters, 13 student chapters, 10 Technical Divisions, and 9 General Interest Committees . . . the AFS Buyers Directory, scheduled for publication in September, will be the first comprehensive buyers guide exclusively for products used by cast metal producers . . . the 36th Annual Apprentice Contest had 472 entries . . . 72 foundries were represented in the 2d Engineered Castings Show . . . the 4th

Registration draws a large crowd Monday morning

Annual Foundry Instructor's Seminar will be held in June at the University of Illinois . . . the AFS Training & Research Institute is presenting 16 courses this year and making plans for a building to house its activities.

The annual business meeting was also the occasion for the presentation of two AFS awards; the Awards of Scientific Merit and the AFS Service Citations. The Awards of Scientific Merit went to Robert H. Mooney, Howard H. Wilder, and Elmer C. Zirzow. Winners of AFS Service Citations were James R. Allan, Bernard D. Clafey, and Roy W. Schroeder. All of these presentations were made by Walter L. Seelbach, chairman of the AFS Board of Awards.

During the business meeting, the first and second place winners in the 1959 Robert E. Kennedy Apprentice Contest were honored. Apprentice contest winners were congratulated by Burton L. Bevis, chairman of the AFS Education Division. Mr. Bevis noted that "As castings become more complex . . . and as competition becomes keener, the need for training becomes greater."

The recommendations of the AFS national nominating committee were announced at the business meeting and affirmative votes were cast for all nominees. Charles E. Nelson was elected president, N. J.

Gold Medal Award winners J. A. Rassenfoss, H. W. Lownie, Jr. and F. J. Walls are congratulated by Walter L. Seelbach.

R. H. Mooney, H. H. Wilder and E. C. Zirzow receive **Scientific Merit Awards** from Walter L. Seelbach.

Walter L. Seelbach presents **Service Citation** to J. R. Allan, B. D. Claffey and R. W. Schroeder.

Dunbeck was elected vice-president, and the following were elected to regular, three-year terms as directors of the society: Norman N. Amrhein, Robert E. Mittlestead, A. J. Moore, W. H. Oliver, L. J. Pedicini, and James N. Wessel.

D. L. Colwell was earlier elected to the AFS Board of Directors by the members of the board itself, in accordance with the bylaws.

President Lewis H. Durdin presided at the AFS Annual Banquet which attracted a crowd of 510. Features of the evening's program were the presentation of three AFS Gold Medals, and a humorous speech on "Solutions for Problems That Don't Exist" by Warren Whitney, James B. Clow & Sons, Inc.

The John H. Whiting Gold Medal was presented to Harold W. Lownie, Jr.; John A. Rassenfoss was recipient of the Peter L. Simpson Medal; and Fred J. Walls won the John A. Penton Medal.

Metalcasting exhibitors at the Engineered Castings Show were encouraged by many designers showing a strong preference toward use of metalcastings wherever feasible. In this view of Show prospective castings users and producers are discussing such attributes as economy, versatility and reliability.

Foundrymen, designers and **buyers** go into a huddle at the Show to solve some problems. This group, from Dow Chemical Co., Western Electric Co. and Bell Laboratories, is discussing a new magnesium casting for Nike-Zeus missile.

Report on the

ENGINEERED CASTINGS SHOW

Metalcastings . . . Buyers . . . Designers . . . and Foundrymen

A new era of metalcasting potential was unveiled in technical displays at the Engineered Castings Show. A high tide of positive opinion favoring the use of castings came from the many buyers and designers on hand for the 5-day event.

Representatives from aircraft and missile producers voiced the opinion that their needs for speedy delivery on complex configurations can be met best by the metalcasting process. Buyers of the less glamorous consumer items stated that they like the economy and versatility of foundry techniques.

The blue-ribbon parade of shoppers included representatives from such companies as . . . Martin Aircraft . . . Rocketdyne . . . Aerojet . . . Douglas Aircraft . . . Boeing . . . Thompson Ramo Wooldridge . . . DuPont . . . Western Electric . . . Chrysler . . . Ford . . . General Motors . . . Bendix . . . Caterpillar . . . International Harvester.

Job titles of men looking over the show bracketed the designer-buyer influences . . . development engineer . . . buyer . . . purchasing agent . . . product engineer-castings . . . casting design specialist . . . chief, manufacturing engineering . . . senior materials and process engineer . . . chief buyer . . . design analyst . . . chief inspector . . . casting buyer.

The show ran the complete gamut of metals, techniques and processes. The epitome of dimensional control and accuracy was displayed by investment casters. But close behind were thin-walled intricate configurations cast in plaster and green sand.

Reliability, versatility and economy of metalcasting processes were proven by the exhibition of cast radar wave guides . . . fuel impellers . . . forming mandrels for solid propellants . . . compressors for nuclear power plants . . . thin-walled aerial photographic equipment . . . naval ordnance fire control devices . . . missile launcher rails . . . tire molds . . . cast-to-size automotive stamping dies . . . axle housings . . . brake drums . . . clutch plates . . . cylinder blocks . . . water-cooled tuyeres . . . electrode holders . . . truck tractor fifth wheels.

More highlights of the Engineered Castings Show coming in the June issue of MODERN CASTINGS!

A. A. Adams, Ford Motor Co., inspecting casting made for Ford by **J. V. Olle,** Motor Castings Co.

L. H. Durdin, Dixie Bronze Co., looking over furnace part needed by **C. W. Vokac,** Hydro-Arc Furnace Div., Whiting Corp.

Fabricast Div., GMC, had largest exhibit at Show.

C. I. Miller, Martin-Baltimore, and **C. Stanley,** Aerojet-General Corp., check part made by **J. Curto,** Curto-Ligonier Foundry.

J. W. Hayes, development engineer, and **H. W. Turner, Jr.,** department chief, Western Electric Co., Baltimore, looking over one of 400,000 die cast aluminum cable splice cases used by Western every year. **G. Strohm,** sales engineer, Doehler-Jarvis Div., holds the casting.

Merrill Foote, American Steel Foundries, talking to **J. J. Broecker,** Boeing Airplane Co., Seattle. Background is largest shell mold now in production.

J. C. Graddy, Douglas Aircraft, **Morris Bean,** president, Morris Bean, & Co., **W. R. Clitherow,** Western Electric Co., talk shop while Western Electric engineers show Bean salesman a new casting job ready for quotes.

B. P. Mullin, Thompson Ramo Wooldridge Co., shopping for wave guides and fuel impellers sold by **R. Granquist,** Universal Castings Corp.

A. Lomako, Quality Control Staff, Chrysler Corp., **F. P. Morrow,** Sales Engineer, Superior Fdry., Inc., and **H. M. Wies,** Chrysler Corp., discuss level of quality needed in castings purchased for Chrysler.

R. H. Moore, Bendix Aviation; **J. H. Grieb,** Bendix; **W. A. Dubovick,** Engineered Precision Castings Co., **J. W. Putman,** Engineered Precision; **C. W. Barley,** Bendix; **P. B. Gross,** Bendix, discussing wave guide castings made by Engineered Precision Castings Co.

H. C. Foster, Gillet & Eaton, Inc., tells a designer how their foundry has solved piston problems by casting alloy iron cap into aluminum diesel piston.

C. W. Kujak, Wilton Tool Mfg. Co., listens to **C. M. Powers,** Neenah Foundry, tell how Neenah can meet his needs for gray and ductile iron vices and clamps.

J. A. Nock, Rausch Mfg. Co., discusses precision cast fire-control safety device with **A. J. Novotny,** Naval Ordnance Laboratory.

On right, **A. Py,** Unit Crane & Shovel Co., discusses purchase of steel castings from **M. Mee,** Crucible Steel Casting Co., Consolidated Fdys. Corp.

G. M. Kutchman, W. A. Kates Co.; **L. S. Krueger,** and **A. M. Slichter,** Pelton Steel Castings Co.; **S. W. Allen,** engineer, W. A. Kates Co.

G. Nevius, East St. Louis Castings Co., shows casting to **D. Siever, W. E. Morehead, A. B. Johnson** and **J. Bond,** Caterpillar team that buys 20,000 tons of castings yearly.

N. H. Caflisch, Foundry Sales, Brillion Iron Works, shows shell molded gray iron casting to **O. L. Borgerson,** Casting Buyer, Fisher Governor Co., which buys 6000 tons of castings a year for automatic controls.

J. M. Tarnow, Chrysler Corp., looks at gray iron transmission casting sold to him by **E. A. Bodner,** Lynchburg Foundry Co.

C. Miller, Martin-Baltimore; **R. A. Pinto,** American Brake Shoe Co.; **J. Katz,** Martin Co.; **P. H. Clapp,** American Brake Shoe Co.; and **R. G. Herzog,** Martin Co., examine ductile iron launcher track for La-Crosse missile.

R. J. Erisman, and **L. A. Grotto,** International Harvester Co., inspecting aluminum diesel engine block sold by **William Pankratz,** Quality Aluminum Castings Co.

C. H. Gibson, Benjamin Electric; **C. S. Wright,** Waukesha Fdy.; and **H. W. Alden;** Ex-Cell-O Corp., in a buy-sell huddle.

Report on the TECHNICAL PROGRAM

Overflow attendance at technical sessions, seminars, shop courses and round-table luncheons were visual proof of the high level of interest that pervaded the 63d Castings Congress.

Most of the more than 95 technical papers presented either have been or will be published in MODERN CASTINGS. However for the convenience of being able to scan the high-lights of metalcasting technology unveiled during the Congress, MODERN CASTINGS presents here a brief abstract of the talks presented. Those not covered in this issue will appear in June.

BRASS AND BRONZE PAPERS

Some Foundry Problems in the Development of a New Marine Propeller Alloy *by A. J. Smith.* The author described some of the problems, and solutions, involved in the development of casting practices for a new nickle-aluminum-bronze alloy for marine propellers . . . . . **Electrical Conductivity of Sand-Cast Copper-Base Alloys *by D. G. Schmidt and F. L. Riddell.*** The electrical conductivities of over 100 sand-cast copper-base alloys have been determined by the authors . . . . . **Relation of Thermal Gradients During Solidification to Pressure Tightness of 85-5-5-5 Bronze *by R. A. Flinn and C. R. Mielke.*** The authors described an investigation whose purpose was to measure the thermal gradients of 85-5-5-5 bronze during solidification to provide a quantitative evaluation of different risering and chilling combinations . . . . . **Research in Progress in Industry: Getting Castings Back into the Foundry *by R. R. Ashley.*** Mr. Ashley described how the use of blown CO_2 cores and molds helped his foundry to compete against other forms of fabrication. **Research and Development on Design of Bronze Sleeve Bearings *by G. E. Langford.*** Mr. Langford described the formation of the Cast Bronze Bearing Institute. **Properties and Composition of Cast Copper-Nickle Alloys *by S. Goldspiel.*** Mr. Goldspiel described investigations into the mechanical properties of two cupro-nickle alloys series. **Research on 90-10 Cupro-Nickel Castings *by E. F. Tibbetts.*** Mr. Tibbetts described production work done in an effort to find an alloy for heavy-wall castings in pressure applications . . . . . **Brass and Bronze Seminar: The Metallurgical and Foundry Aspects of Quality Control. Speakers: C. W. Ward, S. Goldspiel, and A. J. Smith.** Mr. Ward reviewed all inspection processes and noted that visual tests reveal external defects while fracture tests are used to evaluate internal quality. Mr. Goldspiel described development of a reliable set of reference radiographs under leadership of the Bureau of Ships. Mr. Smith noted that the design engineer should consult with the foundryman on the location of tensile test specimens removed from the actual castings . . . . . **Brass and Bronze Round Table Luncheon: Why Use Brass and Bronze Castings. The Physical and Mechanical Properties of Bronze Alloys *by John Kura.*** Mr. Kura stated that the principle reason brass and bronze castings are not applied more often by design engineers is the lack of proper engineering data on

G. Found addresses die cast session. . .

SH&AP session chairmen and speakers. .

Author breakfasts acquainted principals.

Brass & Bronze Tuesday luncheon was devoted to outlining the advantages to customers in using brass and bronze castings.

Brass & Bronze quality control seminar included three technical papers dealing with metallurgy and testing techniques.

their physical and mechanical properties. ***Where General Motors Corp. Would Like to Use Copper-Base Alloy Castings by H. C. Tyree.*** Mr. Tyree ascribed the decreased use of copper-base castings in automotive and heavy industrial applications to the high and fluctuating price of the raw material and to lack of development of cost-saving production methods. ***Cast Copper-Base Alloys for Corrosive Environments by C. L. Bulow.*** Mr. Bulow stated the advantages and disadvantages of various brass and bronze alloys for application to corrosive situations.

DIE CASTING AND PERMANENT MOLD PAPERS

Gray Iron Permanent Molding by H. U. McClelland. The author presented the history of gray iron permanent molding, a description of the process and methods used in design and fabrication of the molds. The metallurgy and dimensional tolerances of the castings produced was discussed . . . . . ***A Hypereutectic Al-Si Alloy by Rolf Kissling and Oldrich Tichy.*** The authors described the development and properties of a die casting alloy suitable to an all-aluminum automotive engine block. They reported that the alloy has been applied to small gasoline engines and is suitable piston and brake assembly components . . . . . ***Thermal Aspects of Cyclic Permanent Mold Operation by C. L. Goodwin and H. Y. Hunsicker.*** The authors described an experimental program during which it was found that mold temperatures, casting solidification rates and permissible speeds of operation are influenced more by casting thickness than by mold thickness . . . . . ***Aluminum Die Casting Metal Cost by G. H. Found and John Lapin.*** The authors presented a method of establishing the value of factors contributing to metal cost in an overall operation and in an individual casting. A review of practices for minimizing metal costs was also presented . . . . . ***Cast Surface Evaluation for Roughness Standards by Eldon Swing.*** The author described a method of evaluating a surface roughness gage. In the method described, a view is obtained by cutting a section through the surface. A photomicrograph of the edge is made and the surface evaluated by obtaining linear measurements from the photo. Measurements are then converted to roughness height rating values by mathematical average . . . . . ***A new Aluminum Die Casting Alloy by J. H. Moorman and E. V. Blackmun.*** The authors announced development of a new aluminum die casting alloy containing approximately 8% silicon, 0.3% magnesium, and 0.03% beryllium. They stated that the alloy combines high strength and ductility with castability superior to currently available alloys . . . . . ***Die Casting and Permanent Mold Luncheon: Vacuum Die Casting by G. R. Morton.*** The speaker described the design features of a high-speed vacuum die casting machine capable of producing over 300 shots of aluminum per hour.

EDUCATION PAPER

New Skills Required for the Shell Process by H. C. Grant. The author described the various techniques that comprise the shell process for pro-

Management luncheon speakers dealt with problem of developing key personnel.

Dr. W. K. Beek started the Malleable Division program with a Monday paper.

Brass & Bronze luncheon on Tuesday completed the division's activities.

Malleable Division luncheon head table includes F. Jacobs, V. Lindner, F. B. Rote, J. H. Lansing and Eric Welander.

Pattern session on Tuesday combined talk on rigging core box and panel discussion on offering consulting service.

ducing molds and cores. Work-skills involves in these techniques were noted.

INDUSTRIAL ENGINEERING AND COST PAPERS

Practical Industrial Engineering for the Small Foundry by F. E. Noggle. The author describes the application of a system of cost controls to the operations of a foundry with 50 to 100 employees. Methods of determining actual conditions, of devising a specific cost control plan, of training personnel, and of formulating basic standard data were described . . . . . **Profit Management Through Cost Control by R. D. Hill.** Profits can and should be planned for, the author stated. Planned profits depend on cost control, and the success of cost controls are dependent on the support of top management, according to the author . . . . . **The Industrial Engineer as a Potential Executive by M. E. Mundel.** The author stated that, industrial engineering is a built-in management development program. He also stated that such a concept of industrial engineering provides a greater goal for engineers and allows small organizations to attract capable men . . . . . **Time Study and Methods rTaining for Supervisors by John Taylor.** People are not skeptical of a good tool when properly trained in its use, Mr. Taylor stated, and it has been demonstrated that when foundry supervision is trained in time study and methods, the problems of time study and incentives diminish or disappear.

LIGHT METALS PAPERS

Sample for Rapid Measurement of Gas in Aluminum by H. V. Sulinski and S. Lipson. The authors described development of a 4-1/2 minute quantitative test for gas in aluminum. Test involves a single weighing of a 20-cc sample solidified at approximately 0.1 atmospheres . . . . . **How Aircraft Designers Look at Light Metal Castings by A. R. Mead.** Light metal castings could be used in modern aircraft design more than they are at the present time, the author said, if they can be developed to meet the requirement of 60 ksi ultimate strength, 50 ksi yield strength and 5 per cent elongation . . . . . **Design Engineering as Related to Magnesium Castings by G. H. Found.** The author presented his concept of magnesium casting design. He stated that the optimum circumstance is one where service performance can be described and related to available mechanical property data. The resulting structures, he said, can then be evolved into configurations which coincidentally are preferred for best foundry practices . . . . . **Bending Techniques for Evaluation of Cast Materials and Structures by J. C. Graddy.** The author reviewed the accepted practices of inspecting mechanical properties of castings and found them wanting. He described a study of the effect of geometry on bending modulus of rupture specimens of wrought materials and proposed a "shape of the curve" parameter for acceptability of bending specimens . . . . . **Starch Content Effect on a Rammed Graphitic Mold Material for Casting Titanium by H. W. Antes and R. E. Edelman.** The starch content effect on the properties of the rammable gra-

AFS National Director T. E. Curry stops to check winners in apprentice contest.

M. E. Mundel, Milwaukee, explained role of industrial engineering to foundrymen.

Pattern luncheon speaker F. B. Porzel talked on changes due to atomic age.

Light Metals luncheon meeting featured 3-man panel discussion on what test bar means to producer and the user of castings.

Light Metals speakers on opening day included R. E. Edelman and H. W. Antes in front shown with W. H. Johnson, J. G. Kura.

phitic mold material was determined by the authors. A mixture containing 6 per cent starch molded at 120 psi provided molds equivalent to machined graphite in minimizing surface contamination of titanium castings. . . . . **Radiography, Microstructure and Mechanical Properties of Cast Magnesium-Thorium-Zirconium Alloy HK 31A** ***by T. R. Bergstrom and R. G. Bassett.*** The authors have established radiographic inspection standards for HK 31A magnesium alloy castings on the basis of an evaluation of the effect of macrosegregation on the mechanical properties of the cast material . . . . . **Hot Cracking Test for Light Metal Casting Alloys** ***by E. J. Gamber.*** The author described his development of a simple and reproducible test for determining the relative resistance to hot cracking of aluminum and magnesium casting alloys . . . . . **Some Principles for Producing Sound Al-7Mg Alloy Castings** ***by W. H. Johnson and J. G. Kura.*** The authors described the development of principles to govern the production of sound horizontal castings of Al-7Mg alloy. . . . . **Magnesium Castings Alloy EK31XA** ***by K. E. Nelson.*** The author described a magnesium casting alloy containing 3.2 per cent didymium and 0.6 per cent zirconium which is rated with the commercial magnesium-rare earth metal-zirconium alloys as second in castability to the magnesium-aluminum-zinc alloys. The author believes that the alloy should prove attractive to rocket and missile designers . . . . . **Ultrasonic Attenuation in Cast Aluminum** ***by H. Smolen and H. Rosenthal.*** The authors described a series of experiments with cast test plates which showed that the attenuation characteristics are affected by the presence of gas and microshrinkage. The experiments were conducted in a search for a nondestructive test which would surpass radiography in ability to distinguish between the soundness characteristics of premium grade and ordinary grade aluminum castings . . . . . **Light Metals Round Table Luncheon:** ***What Does the Test Bar Mean to the Producer and User of Castings?*** Panel member M. E. Brooks noted that test bars give a convenient method of controlling the quality of heat treatment. Panel member R. L. Heath noted that the only true test is a simulated service test. H. Rosenthal, third member of the panel of speakers, discussed the merits of the new MIL-C-211-80 specification for high strength aluminum castings which requires that test bars be cut from castings.

MALLEABLE PAPERS

Specialized Foundry Statistical Controls Improve Customer Satisfaction ***by B. M. Appleman.*** The author described the major statistical process and job quality controls which have been developed especially for foundry applications at the author's company . . . . . **Malleable Iron, A Magnetic Alloy** ***by W. K. Bock.*** The author has compiled and illustrated the magnetic properties of malleable iron . . . . . **The Effect of Bonding Clays on Pin Holes in Malleable Castings** ***by D. R. Jones and R. E. Grim.*** The authors presented a study of pin hole formation in which they con-

T&RI exhibit attracted much attention.

L. C. Marshall shown at malleable meeting.

Victor Rowell speaks at sand session.

Education Division conducts Tuesday afternoon session.

Vacuum die casting was explained at Die Casting luncheon.

cluded that pin holes are often formed by the evolution of water vapor from certain clay bonds in green sand molds heated above 212 F by molten metal. . . . . **Proper Gating Through Use of Cobalt 60 *by A. J. Karam.*** The author described the application of cobalt 60 to check casting design prior to production, to design gating systems, and to establish inspection standards . . . . . **Proper Interpretation and Technique Using Fluorescent Penetrant for Casting Inspection *by A. R. Lindgren.*** The author presented a discussion of specifications, interpretations, use and economics of this nondestrictive testing technique . . . . . **Mottling in Heavy Section White Iron Castings *by C. R. Loper, Jr. and R. W. Heine.*** This was the first progress report of an investigation of casting heavy section malleable iron sponsored by the Malleable Division, American Foundrymen's Society. The project is aimed at producing heavy section castings from an iron of such composition and/or melting practice that mottling or primary graphitization will not occur during the freezing of the casting . . . . . **Porosity, Inclusions and Pinholes in Malleable Castings *by C. A. Sanders.*** Author Sanders presented his opinion that hot sand and brittle sand are the common sources of inclusions that may cause pinhole porosity in production malleable foundries. The author stated that he feels inclusions are not generally recognized as having a direct relationship to pinhole porosity . . . . . **Chemical Analysis vs. Heat Treatment Effects on Tensile Strength of Malleable Iron Controlled Annealing Committee (6-D) Report *presented by L. R. Jenkins.*** Conclusions determined by the committee's studies were: most foundries have developed an anneal cycle which produces highest properties in their iron; the highest tensiles are developed by the longest cycles; iron of 240 carbon or less produces higher tensiles; there is no difference between Class A and B irons, the designation is outmoded; use of a nitrogen atmosphere does not improve properties but has other advantages . . . . . **Malleable Round Table Luncheon: *Selection of Materials for Ordnance Development by V. Lindner.*** The author described three basic problems that distinguish ordnance development projects from normal, commercial development. These were: the uniqueness of military requirements, the extreme environmental conditions to which ordnance is exposed, and the necessity that ordnance be 100 per cent safe. Mr. Lindner's paper was followed by a film, Toward More Effective Shell, which illustrated the development of the pearlitic malleable cast 81 mm mortar shell . . . . . **Malleable Shop Course: *Machining of Standard and Pearlitic Malleable Iron.*** The subject was presented in three parts. The first, *Technical Aspects of Machinability Testing,* was presented by L. C. Marshall who discussed the methods and the means of measuring machinability. The second part, *Available Machinability Data,* was prereviewed published data and noted sented by W. C. Truckenmiller who data soon to be published. The third part of the program, *Solving Machining Problems,* was presented by George Kramer. Mr. Kramer suggested means of solving actual shop problems and cited several specific examples of problems in machining pearlitic malleable iron parts . . . . . **Malleable Shop Course: *Effect of Melting Variables on the Properties of Malleable Irons by R. W. Heine.*** Professor Heine described the effect of melting variables in the following areas: chemical reactions in melting, motting, and annealability, and physical properties.

PATTERN PAPERS

New Horizons in Pattern Engineering Materials *by J. E. Olson.* The author reports on the repair and manufacture of patterns with solid, plastic-rubber elastomers. The author stated that the testing program did not provide conclusive answers, but that the results of abrasion resistance, impact resistance, and molding tests indicates that the material may be applied to the metalcasting industry . . . . . **Core Boxes for Shell Cores *by J. E. Stock.*** The author described solutions to problems encountered in the production of core boxes for shell cores. He stated that the use of gray iron boxes with hollowed back had proved most satisfactory . . . . . **Construction of, and Materials for, CO_2 Pattern and Core Box equipment *by R. J. Carver.*** The author noted that there is a tendency to overgas when using CO_2 and to thereby unnecessarily increase the cost of core production. It was also noted as advisable to avoid moisture pick-up by storing cores in a dehumidified environment . . . . . **Rigging of Core Boxes for High Production Core Practices *by W. H. Miller.*** The author described rigging that has proved successful in developing a relatively high production standard while requiring minimum core box maintenance . . . . . **Pattern Round Table Luncheon: *Patterns for Survival by F. B. Porzel.*** Atomic energy expert Porzel advised patternmakers that national survival requires recognition that thermonuclear was is virtually race suicide.

SAFETY, HYGIENE & AIR POLLUTION CONTROL PAPERS

Practical Planning for Non-Destructive Testing by Use of Radiation *by F. S. Sutherland.* The general problems concerning non-destructive testing by radiation were considered by the author. These problems are: choice of source or unit, exposure room design, protective materials, fixed and portable sources, and employee considerations . . . . . **Audiometric Testing Programs in Foundry Noise Control *by H. T. Walworth.*** The author defined the foundry noise problem from the standpoint of noise exposure and compension for hearing loss. These problems were then relation to the purposes of audiometric testing programs.

Report on the AFS ELECTIONS

Elected to PRESIDENT

C. E. Nelson
Dow Chemical Co.
Midland, Mich.

Nelson, technical director of the magnesium department, has been engaged in research and development since starting his career with Dow Chemical in 1930. He has held his present position since 1946.

Elected to VICE-PRESIDENT

N. J. DUNBECK
International Minerals & Chemical Corp.
Skokie, Ill.

Dunbeck, vice-president, Industrial Minerals Division, joined Eastern Clay Products, Inc. in 1926 and was vice-president when it was acquired in 1951 by International Minerals & Chemical Corp.

Elected to the BOARD OF DIRECTORS

N. N. AMRHEIN
Federal Malleable Co.
West Allis, Wis.

R. E. MITTLESTEAD
Lectromelt Casting Div.
Akron Standard Mold Co.
Barberton, Ohio

L. J. PEDICINI
Congress Die Casting Div.
Tann Corp.
Detroit

L. H. DURDIN
Dixie Bronze Co.
Birmingham, Ala.

A. J. MOORE
Canadian Bronze Co., Ltd.
Montreal, Que.

W. H. OLIVER
American Radiator & Standard Sanitary Corp.
Buffalo, N.Y.

J. N. WESSEL
Puget Sound Naval Shipyard
Bremerton, Wash.

Report on the APPRENTICE CONTEST

Winning entries in the 1959 Robert E. Kennedy Memorial Apprentice Contest illustrated the scope of the event by including winners from areas ranging from southern California to Quebec. The 1959 contest was the 36th in the series of annual AFS-sponsored programs honoring the late R. E. Kennedy, AFS Secretary Emeritus.

Winners in the five divisions of the contest were selected from 474 individual entries. Fifteen AFS chapters held local area competitions to select entries for the national event, and a record 189 companies also held company-wide contests to select entries.

Chapter contests were held by the following AFS chapters: Canton, Central Illinois, Central Ohio, Detroit, Eastern Canada, Northern Illinois-Southern Wisconsin, Northeastern Ohio, Ontario, Oregon, Philadelphia, St. Louis, Southern California, Twin City, Washington and Wisconsin.

Seven of these chapters have conducted Chapter Apprentice Contests annually since 1950. Three of these seven chapters, Eastern Canada, Northern Illinois-Southern Wisconsin and Wisconsin, were represented by first-place winners in the national contest.

Two of the individual winners also demonstrated the value of consistent effort by placing in the contest for a second time. James Rogers, third place winner in steel molding, placed second in that division in 1958. Ralph Leland, third place winner in non-ferrous molding, won the same position in the 1958 contest.

The winners of the first three places in each of the five divisions received cash prizes of $100, $75 and $50. Winners of first and second places had their transportation paid to the Castings Congress and received their awards in person. The first three place winners in each division had their entries exhibited at the convention.

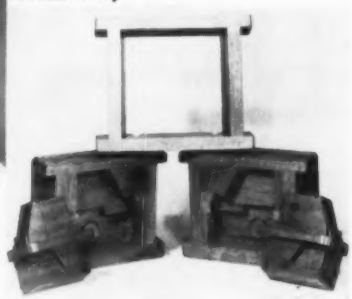
THE NATIONAL APPRENTICE CONTEST WINNERS

WOOD PATTERNMAKING

the winner . . .

Horst N. Prohaska
Caterpillar Tractor Co., Peoria, Ill.

. . . the entry



SECOND PLACE
Darrell A. Giles
Beaver Pattern Co., Detroit

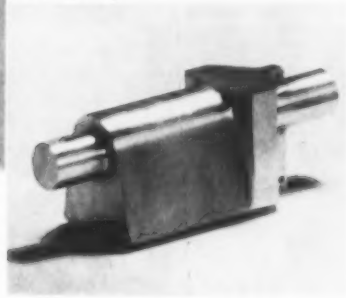
THIRD PLACE
Ray Bunk
Rupp Pattern Co., Rockford, Ill.

METAL PATTERNMAKING

the winner . . .

Louis S. Uveges
Ford Motor Co., Berea, Ohio

. . . the entry



SECOND PLACE
Zane Holowachuk
International Harvester Co., Hamilton, Ont.

THIRD PLACE
S. Gregory Monoc
Ford Motor Co., Berea, Ohio

1959 CASTINGS CONGRESS PAPERS

■ The technical articles appearing in this preview section of MODERN CASTINGS are the official 1959 AFS Castings Congress papers—the most authoritative technical information available to the metalcasting industry.

Nearly 100 technical papers presented at the 63d Castings Congress of the American Foundrymen's Society will be printed here prior to publication of the complete 1959 AFS TRANSACTIONS.

■ Written discussion of these papers is welcomed and will be included in the 1959 TRANSACTIONS if submitted by September 1. Discussions should be addressed to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

■ The complete case-bound volume of 1959 AFS TRANSACTIONS, including all papers and all discussion, will be published December 1. Orders for this volume should be addressed to the Technical Department.

IRON MOLDING

the winner . . .

Forrest R. Wills
Link-Belt Co.,
Philadelphia

. . . the entry

SECOND PLACE
Alfred A. Di Reimo
Brown & Sharpe, Providence, R.I.

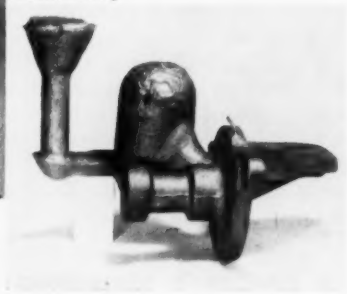
THIRD PLACE
William Gregery
W. O. Larson Fdy. Co., Grafton, Ohio

STEEL MOLDING

the winner . . .

Robert Lord
Dominion Engineering Works,
Montreal, Que.

. . . the entry



SECOND PLACE
Jim Fazio
Atlas Fdy. & Mach. Co., Tacoma, Wash.

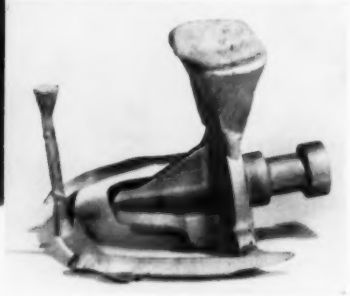
THIRD PLACE
James Rogers
Oregon Steel Fdy. Co., Portland, Ore.

NON-FERROUS MOLDING

the winner . . .

Stanley Graff
Eck Foundries, Inc.,
Manitowoc, Wis.

. . the entry



SECOND PLACE
Ronald McConville
Nordberg Mfg. Co., Milwaukee

THIRD PLACE
Ralph Leland
Alloy Aluminum Fdy. Co., Los Angeles

ULTRASONIC ATTENUATION IN CAST ALUMINUM

By H. Smolen and H. Rosenthal

ABSTRACT

In the past few years, techniques have been developed for producing high quality aluminum castings. Since radiography does not clearly distinguish the difference between this quality and the ordinarily acceptable grade, there is a need for a nondestructive test method for this purpose. Aluminum test plates (7 per cent Si — 0.3 per cent Mg) were cast with a chill on one edge and a riser at the opposite edge. Near the chill the properties are 38,000 psi ultimate tensile strength, 26,000 psi yield strength and 8 per cent elongation. Near the riser the properties fall off to 33,000 psi ultimate tensile strength, 26,000 psi yield strength and 2 per cent elongation.

Radiographic examination was not sensitive to this change. Ultrasonic attenuation measurements were made at various locations in the plates. There was a definite increase in attenuation in a direction away from the chill edge. Other experiments have been made on samples (5 per cent Si) with various gas contents. It is shown that the attenuation characteristics are markedly affected by the presence of gas and microshrinkage in the samples. Techniques for making ultrasonic attenuation measurements on commercial castings were not considered in this paper.

INTRODUCTION

High-strength, high-ductility aluminum castings have recently become a commercial reality, as shown by the issuance of a standard specification: MIL-C-21180 (Aer), Dec. 5, 1957. The technical developments leading to the adoption of the specification are reviewed by Flemings and Taylor.[1] It is now apparent that these high quality castings will find increasing application in aircraft, missiles and other areas where they will be critically stressed to take advantage of their strength-to-weight ratio.

A necessary consideration in the use of such castings is efficient inspection methods for detecting harmful flaws. Much stress is rightfully placed on the technique of sectioning sample castings to determine test bar properties at selected locations. In addition, 100 per cent x-ray inspection is necessary to eliminate castings with random flaws or excessive porosity.

The purpose of the work described here is to enlarge the scope of inspection which can be non-destructively applied to each casting. Harris and Crowther[2] have recently reviewed the use of ultrasonic testing on aluminum ingots as well as wrought products including plates, extrusions and forgings. Ultrasonic techniques have been used successfully to detect irregularities such as inclusions, porosity and shrinkage holes in large, ferrous castings,[3] in nonferrous cast billets[4] and in arc-cast zirconium and other light alloy ingots.[5]

Although these studies are not directly applicable to the problem of sand-cast aluminum, it is indicated that ultrasonics is potentially a more refined technique than radiography. This is especially important in view of the fact that radiography is of limited usefulness in distinguishing between ordinary levels of soundness, as compared to the soundness characteristic of a premium grade casting.

ULTRASONIC TECHNIQUES

Commercially available ultrasonic test equipment was used throughout the investigation. The equipment is a combined pulse generator and signal receiver. Pulses of electrical energy, generated at test frequencies of 0.5, 1.0, 2.25 or 5 megacycles per sec, are applied to an X-cut piezoelectric quartz crystal transducer and converted into mechanical vibrations.

The mechanical vibrations are coupled into the test piece through a thin layer of couplant (glycerine and aerosol), and continue to travel back and forth through the test piece until the total impinging ultrasonic energy pulse is exhausted. Each return to the transducer is converted to an electrical signal which is detected by the receiver, amplified and displayed on a cathode ray tube screen as a vertical "pip."

Porosity within a test piece tends to cause absorption and scatter of the impinging ultrasonic energy. In setting up an investigation, it is first necessary to find a test frequency capable of penetrating the material. As the frequency is decreased (i.e., the wave length is increased), less absorption and scatter occur and better penetration can be realized.

Initially, all samples of both alloys studied were examined at various test frequencies. It was found that the best definition of porosity content was obtained using a test frequency of 1.0 megacycle per sec on the 5 per cent silicon alloy sample, and of 2.25 megacycles per sec on the 7 per cent silicon–0.3 per cent magnesium alloy.

5 PER CENT SILICON SAMPLES

Castings were made, as shown in Figs. 1 and 2. Pouring temperature was 1288 F (698 C). One casting was poured from a heat degassed for 10 min with

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chlorine (Group I), one from a heat which was untreated (Group II) and one from a heat which was poled 2 min with green wood (Group III). Each casting consisted of five samples which were cast simultaneously from a central hub with different sized gates. Each sample was identified as to pre-pour treatment (Group I, II or III) and gate size (A, B, C, D or E).

The samples in Group I were designed to be least porous, Group II more porous and Group III most porous. In addition, the smaller the gate size the more porous a sample was likely to be. Therefore, sample IE was expected to be the least porous, and sample IIIA the most porous of all the castings studied. The samples were machined just enough to remove the rough skin typical of sand castings in order to provide an adequate surface finish for x-ray. Radiographs were taken of each casting to establish its porosity content. Standard 250 kv x-ray equipment was used.

Figure 3 shows where each specimen was ultrasonically examined at positions designated head, center and base.

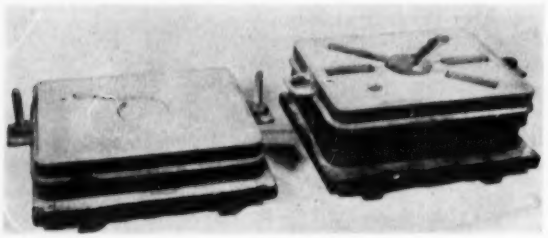


Fig. 1 — Sand mold in which samples were cast.

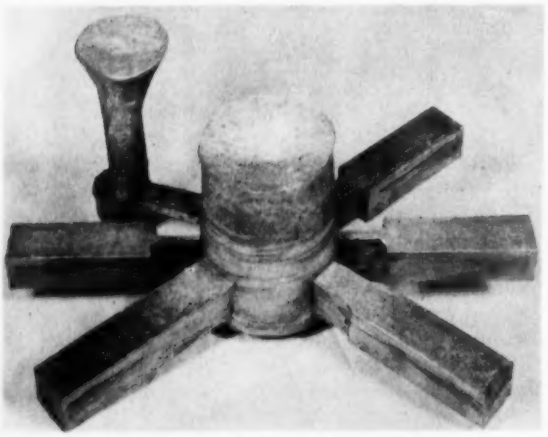
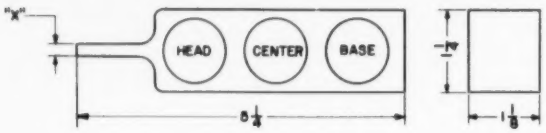


Fig. 2 — Samples as-cast showing riser and gating.



GATE	A	B	C	D	E
X	3/16	5/16	9/16	7/8	1 1/4

Fig. 3 — Line drawing of sample bar showing ultrasonic test positions.

Figure 4 contains the radiograms and reflectograms obtained on all samples tested. In those cases where the same ultrasonic pattern was obtained at the three positions examined on a given test bar, only one reflectogram was taken. Where variations in ultrasonic return on a given test bar were observed, reflectograms were taken of the maximum and minimum return.

The reflectograms showed a consistent change in the amplitude and/or number of back reflections observed. The change is evident in comparing the results obtained on the samples in Group I (least porous), as opposed to those of the samples in Group II (more porous) or Group III (most porous). For a given gate size, ultrasonic attenuation increased as porosity increased, i.e., the ultrasonic return observed on samples in Group I was greater than that observed on samples in Group II, which in turn was greater than that observed on samples in Group III.

Variations in the porosity content within any one sample were readily apparent. The head sections of samples with the smaller gate sizes tended to be more porous than the base sections, as verified by the radiograms. The reflectograms showed that ultrasonic attenuation tended to increase at the head sections.

The radiograms did not show any marked difference in the porosity content of samples in Group II, compared with those in Group III. However, radiograms of the samples in Group I were consistently darker than the others obtained, verifying that these were the least porous studied.

Figure 5a is a reflectogram showing the ultrasonic return observed when a wrought aluminum standard test block (24ST alloy) was examined in a flaw-free area at a test frequency of 1 megacycle per sec. Note that the somewhat bulbous return characteristic of the castings is replaced by sharp "pips," each "pip" representing an echo (back reflection) returned from the bottom surface of the wrought bar.

Figure 5b is a reflectogram taken at the same area of the standard block with the test frequency increased to 2.25 megacycles per sec.

7 PER CENT SILICON — 0.3 PER CENT MAGNESIUM SAMPLES

Four test plates were specially prepared to have a gradient of mechanical properties ranging from premium quality to ordinary sand-cast quality. As shown in Fig. 6, the plates were cast horizontally in green sand. The metal was poured down a 1 in. diameter sprue connected centrally with a runner lying parallel to the 8-in. side of the plate. Two cross runners, attached to the top of the main runner, led the metal directly into the plate. Along this edge of the plate there was a riser running the full 8-in. length, its height was 3 in. and it tapered slightly to a base 2 in. wide.

On the opposite 8-in. side of the plate there were two evaporative water-type chills. These chills consisted of water-filled tubes closed on the bottom. The open end extended above the surface of the sand mold. As illustrated, there were integral lugs on the plate which surrounded the base of these tubes. In practice, the molten metal ran into these lugs, sur-

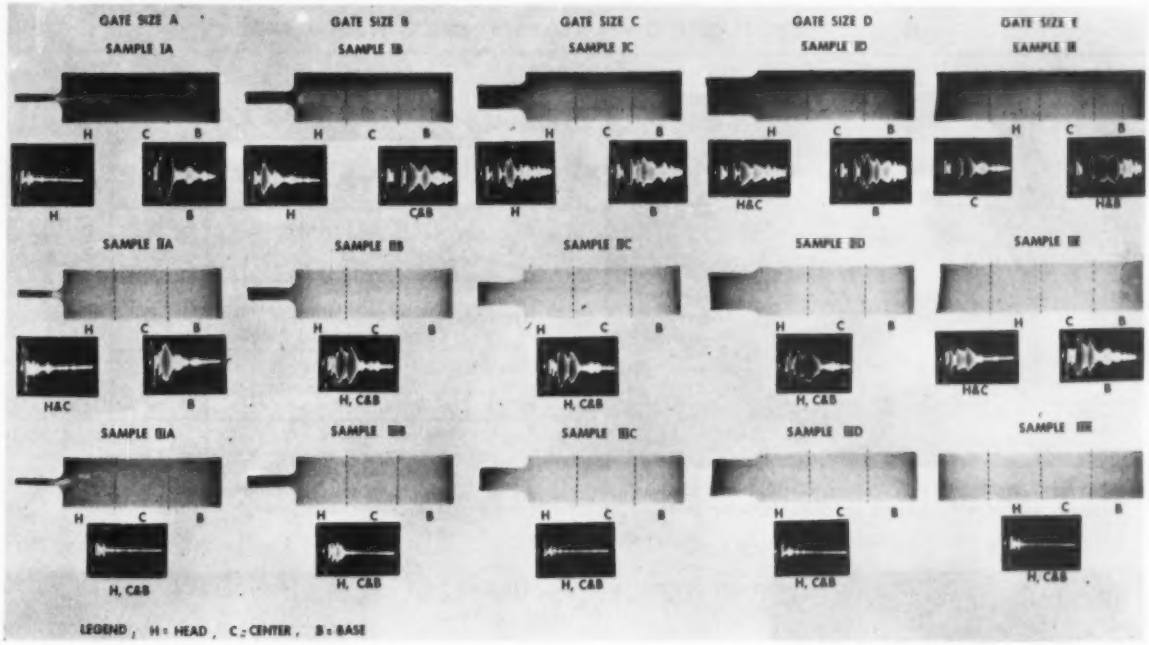


Fig. 4 — Radiograms and reflectograms of samples studied.

rounded the tube and caused the water to boil. So long as water remained available, the temperature in the inner part of the tube could not rise above 212 F (100 C). The result was an efficient chill which occupied a small mold volume.

Two heats of aluminum alloy 356 were induction melted. Two plates were poured from each heat. The metal in plates 1 and 2 (heat 1) was melted, brought to 1350 F (732 C) and poured. Metal in plates 3 and 4 (heat 2) was melted, degassed 10 min at 1300 F (704 C) by chlorine flushing and then poured at 1350 F (732 C). It was anticipated that there would be little or no porosity at the chill edge, and a gradual increase in porosity content as the distance from the chill edge increased.

The plates were machined to a surface finish of approximately 250 micro-in. (rms) and x-rayed. Each was marked off into 16 test positions measuring approximately 1.5 by 2 in. and numbered. Test positions 1 through 4 located at the chill edge were designated Zone A, positions 5 through 8 were designated Zone B, 9 through 12, Zone C and 13 through 16, the area under the riser, Zone D (Fig. 7). Ultrasonic measurements were made of each test position on each plate.

The data are listed in Table 1. The number of back reflections observed at each test position with an amplitude greater than three instrument scale divisions (half-peak) is recorded in column "E" (echoes above three instrument scale divisions). The amplitude of the first back reflection which measured less than or equal to three divisions (half peak) is recorded in column "H" (next echo height).

Reflectograms (Fig. 8) were taken of the ultrasonic return observed at positions 2 (Zone A), 6 (Zone B), 10 (Zone C) and 14 (Zone D) on plate 2 (not degassed) and plate 3 (degassed 10 min by chlorine). The reflectograms clearly show the tendency of ultrasonic attenuation to increase with an increase in distance from the chill edge, and are representative of the patterns observed throughout the the tests.

Plates 2 and 3 were then heat treated to the T-6 condition, and the ultrasonic measurements were repeated. The data obtained are also recorded in Table 1. Plates 1 and 4 were cut into 16 blocks, each block representing an ultrasonic test position (Fig.7), and the density of each was measured by weighing in air

Fig. 5a
A — Initial pulse.
B — First back reflection.
C — Second back reflection.
D — Third back reflection.
E — Fourth back reflection.
F — Fifth back reflection.

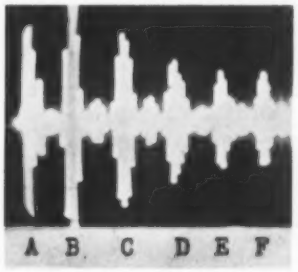


Fig. 5b
A — Initial pulse.
B — First back reflection.
C — Second back reflection.
D — Third back reflection.
E — Fourth back reflection.
F — Fifth back reflection.

Fig. 5 — Reflectograms taken on flaw-free wrought aluminum bar at test frequencies of 1 megacycle/sec (5a) and 2.25 megacycles/sec (5b).

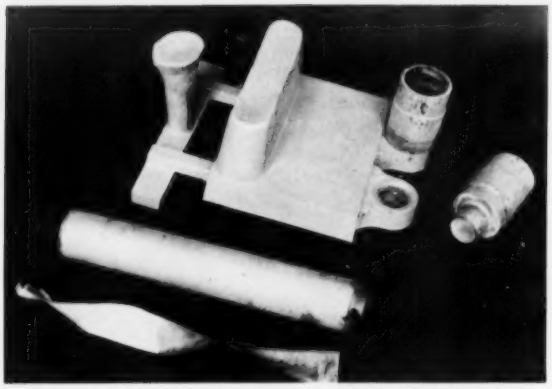


Fig. 6 — Casting showing gating, risering and chilling arrangement of a 8 x 6 x 1¼ in. cast 356 alloy plate.

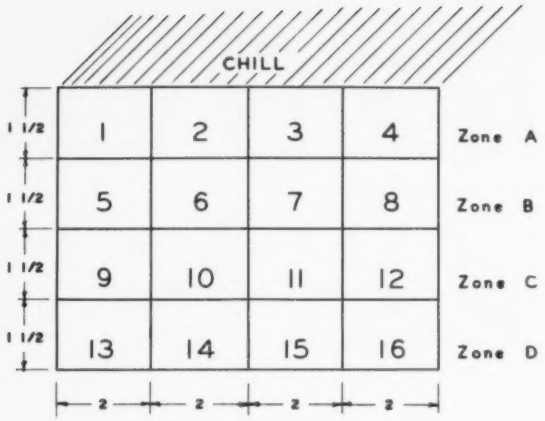


Fig. 7 — Line drawing of sample plate showing ultrasonic test positions and zones.

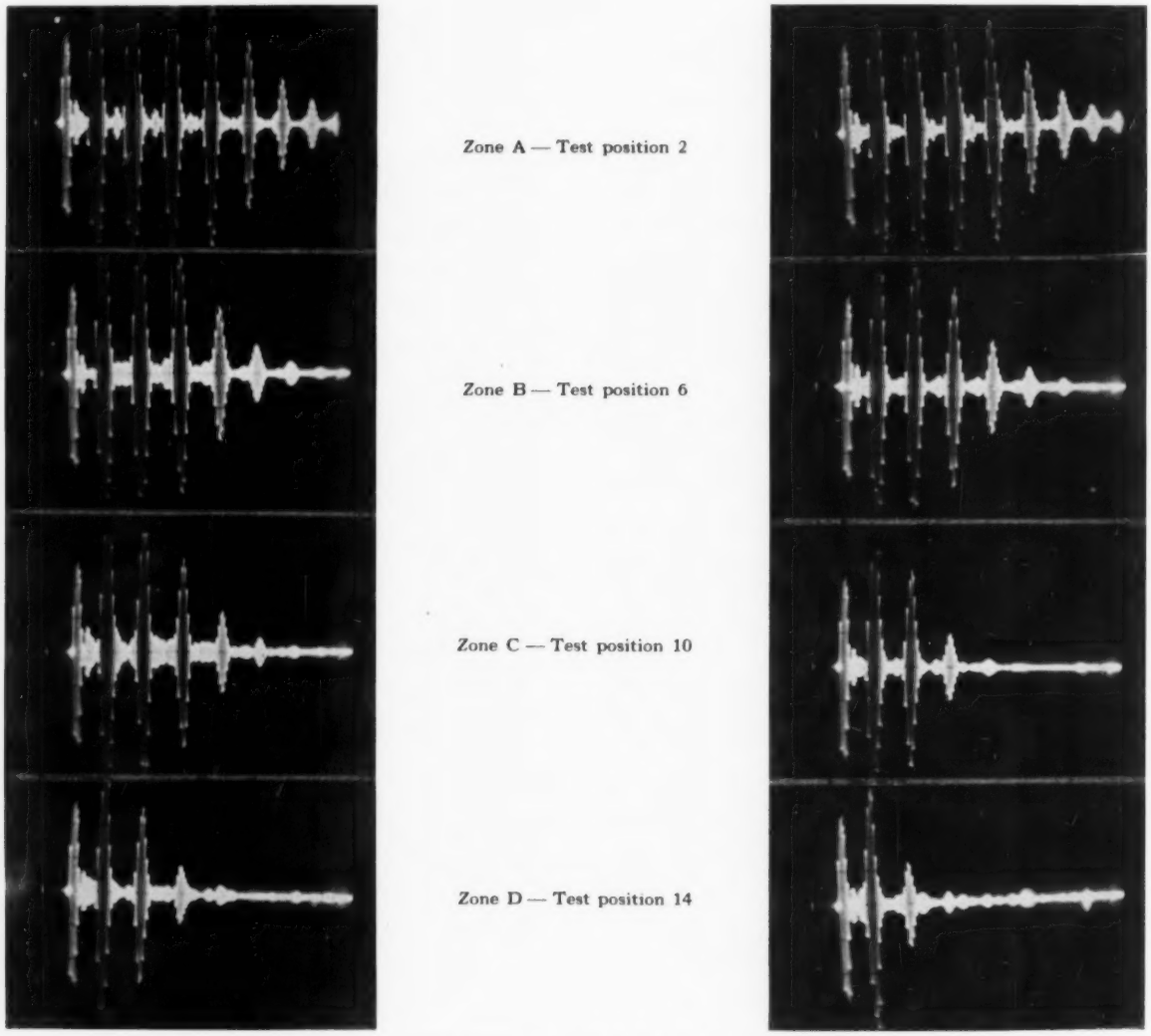


Fig. 8 — Typical ultrasonic test patterns observed. Plate 2, left (not degassed). Plate 3, right (degassed).

TABLE 1 — ULTRASONIC TEST DATA ON CHILLED PLATES (2.25 MCS)

Position Number	Plate 1 (AC)			Plate 2 (AC)			Plate 2 (HT)			Plate 3 (AC)			Plate 3 (HT)			Plate 4 (AC)		
	E	XE	H	E	XE	H	E	XE	H	E	XE	H	E	XE	H	E	XE	H
Zone A																		
1	4		2.3	4		2.0	3		2.9	4		2.0	4		2.4	3		2.0
2	4	4.0	2.7	4	4.0	2.5	4	3.75	2.1	4	4.0	2.0	4	4.0	2.3	4	3.5	2.0
3	4		2.5	4		2.5	4		2.4	4		2.2	4		2.7	4		2.3
4	4		1.6	4		2.1	4		2.0	4		2.2	4		2.7	3		2.8
Zone B																		
5	3		2.2	3		2.8	3		2.7	3		2.2	3		2.7	2		3.0
6	3	3.0	2.3	3	3.0	2.0	3	3.0	1.8	2	2.5	3.0	3	2.75	1.6	2	2.0	2.2
7	3		1.4	3		2.1	3		2.2	2		2.5	2		3.0	2		2.7
8	3		2.1	3		2.6	3		2.2	3		1.7	3		2.2	2		2.8
Zone C																		
9	2		2.8	2		3.0	2		2.9	2		2.0	2		2.3	2		1.3
10	2	2.0	2.1	2	2.0	2.7	2	2.0	2.7	1	1.5	2.8	1	1.75	2.9	2	1.5	1.4
11	2		2.0	2		2.5	2		2.1	1		1.9	2		1.5	1		2.5
12	2		2.1	2		3.0	2		3.0	2		2.3	2		2.8	1		2.9
Zone D																		
13	2		2.5	2		2.9	2		3.0	1		3.0	2		1.8	1		2.5
14	1	1.5	2.7	1	1.5	2.5	1	1.5	2.3	1	1.25	1.1	1	1.5	1.5	1	1.0	1.6
15	1		2.2	1		1.5	1		2.5	1		0.6	1		1.0	1		1.6
16	2		1.6	2		2.5	2		2.8	2		1.6	2		2.1	1		2.7

E = Echoes above 3 instrument scale divisions.
XE = Average number of echoes above 3 instrument scale divisions observed at each zone.
H = Next echo height (in divisions).
AC = As cast.
HT = Heat treated.

and alcohol. These measurements are recorded in Table 2.

At the time the plates used in this study were fabricated, two additional plates were cast under the identical conditions used for plates 3 and 4. They were heat treated to the T-6 conditions and cut into 0.505 in. diameter tensile test bars. Ultimate tensile strength, yield strength and per cent elongation were determined. The mechanical property data obtained are graphed in Fig. 9.

DISCUSSION

There were not enough plates tested to draw any firm conclusions on the difference between the chlorine treated and untreated, or the as-cast vs. heat-treated specimens. However, in general, Table 1 indicates that there was little difference between the ultrasonic attenuation characteristic of plates which were chlorine treated and those which were not, or between plates which were heat treated and those which were not.

It is not surprising that chlorine degassing has no apparent effect under the experimental conditions employed. With the use of clean ingot, induction melting and avoidance of overheating, it is well known that gas pickup by the melt is negligible. A degassing treatment is a worthwhile precautionary measure which, in this case, proved unnecessary.

The testing of plates in the as-cast condition, as well as the heat-treated condition, was done to confirm what was theoretically expected. Although the form and distribution of the precipitates in the microstructure are altered by the heat treatment, it is improbable that these fine scale changes would be detectable except at a much higher frequency than that used in these tests.

A study of Table 1 shows that the zone-to-zone variation in the ultrasonic response observed on plates 1 and 2 in the as-cast state was consistent, as was that observed on plates 3 and 4 as-cast, indicating the good reproducibility of ultrasonic measurements for any one pre-cast treatment. It can be seen that the spread of ultrasonic attenuation values for any given zone is quite narrow.

Table 2 shows that the density measurements of plates 1 and 4 were essentially the same, so that a combined average density is also shown for each zone.

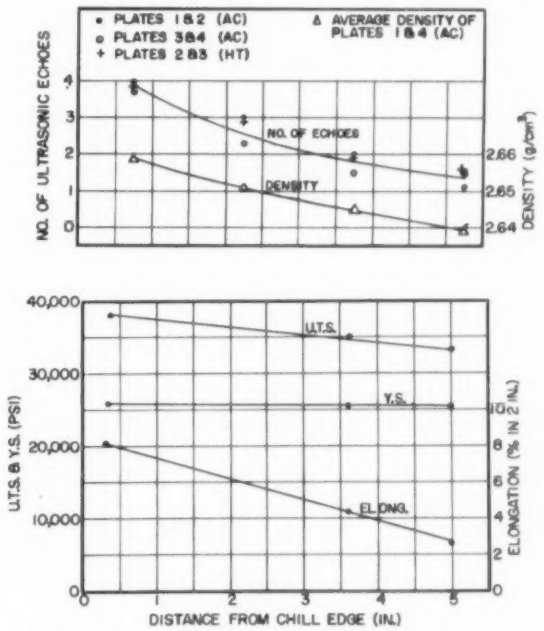


Fig. 9 — Graph showing variation in number of ultrasonic echoes, density and tensile properties with increased distance from chill edge.

TABLE 2 — DENSITY MEASUREMENTS OF PLATE 1 AND PLATE 4 AT EACH TEST POSITION

Position Number	Density (g/cm³) Plate 1	Plate 4	x̄
Zone A			
1	2.65	2.66	
2	2.66	2.66	2.659
3	2.66	2.66	
4	2.66	2.66	
Zone B			
5	2.65	2.65	
6	2.66	2.65	2.651
7	2.65	2.65	
8	2.65	2.65	
Zone C			
9	2.64	2.65	
10	2.65	2.65	2.645
11	2.65	2.64	
12	2.64	2.64	
Zone D			
13	2.64	2.64	
14	2.64	2.64	2.639
15	2.64	2.63	
16	2.64	2.64	

x̄ = Combined average density of each zone in plate 1 and plate 4.

The density change amounts to 0.8 per cent over the 5-in. range, i.e., from Zone A (closest to the chill), to Zone D (farthest from the chill). Detection of a 2 per cent density change by radiography is usual by normal techniques, but careful control of radiographic variables is required to detect voids 0.5 to 1 per cent of the thickness.[6] Figure 10, a radiograph of test plate 3, shows the relative insensitivity of the x-ray method used to the detection of small density changes in the chilled plate.

Figure 9 illustrates the relationship between proximity to chill and a number of variables dependent on this distance.

The yield strength is unaffected by the chill distance. This is consistent with the general observation that yield strength in cast alloys is relatively independent of porosity. There is a moderate decline in ultimate tensile strength of 13 per cent from a position 0.5 in. from the chill to a position 5 in. away. As might be expected, the most marked decline is shown by the elongation, which falls to one quarter of its value over the same distance.

Fig. 9 also shows the excellent correlation of ultrasonic attenuation with both density and tensile properties. The ultrasonic attenuation data graphed were taken from Table 1. In order to simplify comparison of plates which were chlorine degassed and those which were untreated, the data for plates 1 and 2 were combined, as were data for plates 3 and 4. Again it is seen that the chlorine degassing treatment had little effect. The combined data for plates 2 and 3 in the T-6 heat-treated condition are also plotted. It can be seen that heat treatment does not affect ultrasonic attenuation at the test frequency used.

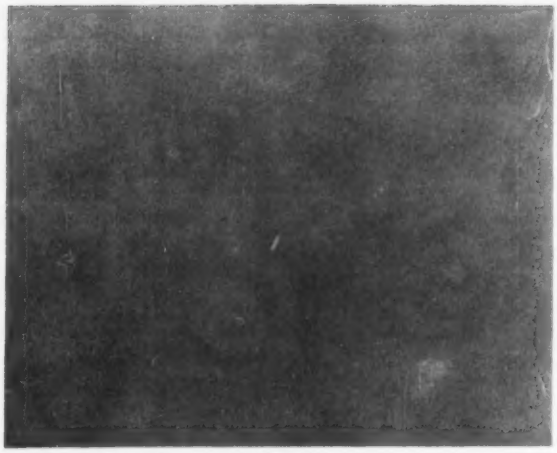


Fig. 10 — Radiogram of plate 3.

CONCLUSIONS

1) Ultrasonic attenuation is sensitive to both small and large changes in the porosity content of aluminum castings.
2) Ultrasonic attenuation shows a clear correlation with the measured mechanical property gradients in a chilled plate casting.
3) Ultrasonic attenuation appears to be more sensitive than radiography in the evaluation of porosity content.
4) In principle, ultrasonic attenuation can be used to differentiate between aluminum castings of premium quality vs. ordinary quality.

ACKNOWLEDGMENTS

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REFERENCES

1. M. C. Flemings and H. F. Taylor, "Adapting Theory to Practice in the Manufacture of Light Metal Castings," 25th International Foundry Congress, Paper No. 9 (1958).
2. J. G. Harris and J. Crowther, "The Use of Ultrasonic Testing for the Control of Quality in the Manufacture of Aluminum Alloys and Other Non-ferrous Materials," *Journal of the Institute of Metals, vol. 86* (5), p. 193-207 (1958).
3. Sperry Products, Inc., Technical Data No. 50-713.
4. S. L. Fry, "Non-Destructive Testing in the Control of Quality of Non-ferrous Castings," *Journal of the Institute of Metals, vol. 85* (8), p. 361-366, 1957.
5. F. W. Wood and J. O. Borg, *Ultrasonic Inspection of Arc-Cast Zirconium and Light Alloys,* U.S. Bureau of Mines Report No. 5126, (1955).
6. K. R. Van Horn, "Radiography of Metals," *Metals Handbook,* American Society for Metals, Cleveland, Ohio, p. 143, 1948.

CARBON FLOTATION IN DUCTILE IRON

By A. H. Rauch, J. B. Peck and G. F. Thomas

ABSTRACT

In hypereutectic ductile iron castings, carbon in excess of that necessary to maintain a carbon equivalent (C.E. = % T.C. + ⅓% Si) of 4.55 per cent, was found to be precipitated during the solidification period. The precipitated carbon is floated to the top surface of the casting, where it is trapped, resulting in an area of high graphite nodule concentration. The flotation of carbon also occurs in the ladle in the time interval between silicon inoculation and pouring of the castings.

INTRODUCTION

As part of the control procedure in the ductile iron operation at the authors' company, pins are cast in a permanent mold from a 1500 lb transfer ladle immediately after inoculation with ferrosilicon at the cupola. The carbon content of these pins was found to be significantly greater in some instances than the amount found in pins poured from a 400 lb pouring ladle on the foundry floor with iron from the same transfer ladle. A further discrepancy was noted between the carbon content of the cast pins and the carbon content of a Y block test bar poured from the same ladle.

The discrepancy between the carbon content obtained by the analysis of chilled pins, and the analysis of wafers cut from test bars, was at first ascribed to the lack of accuracy of the latter procedure. However, subsequent work showed that the analysis of wafers is an acceptable technique for carbon determination, and that the discrepancies between ladle analyses and between test bar and ladle analyses could be explained on the basis of silicon and carbon contents (carbon equivalent) and temperature.

This led to an investigation of the flotation of graphite that is occasionally observed in nodular iron castings. Graphite flotation was noted by Kuniansky* in sand casting where hypereutecticity was pronounced. The graphite flotation phenomenon was differentiated from dross flotation or cope defect.

PROCEDURE

Nodular base iron is melted in a water cooled cupola using basic slag practice, and tapped into a forehearth containing 3000-4500 lb of metal. From the forehearth, 1500 lb of metal is weighed into a treating ladle containing the magnesium alloys, and subsequently poured into a transfer ladle where it is inoculated with 85 per cent ferrosilicon. The iron is then taken to the foundry floor where it is transferred to 400 lb pouring ladles for filling the molds.

Chilled pins, 0.135 in. in diameter, are poured immediately after the silicon inoculation (called cupola pins), and after pouring a 1-in. Y block casting on the foundry floor (called foundry pins). Carbon loss from the time of the silicon inoculation until pouring of the Y block casting was determined by comparing the carbon analysis of the cupola pin with the carbon analysis of the foundry pin. Eighty-three observations were made.

The carbon loss of the metal during solidification was determined by comparison of the carbon analysis of the foundry pins with that of the bottom inch of the Y block. For this portion of the investigation, 128 observations were made.

Carbon analysis of the chilled pins was made on pulverized samples. Carbon analysis of the Y block castings was made on a wafer approximately $\frac{1}{16}$-in. thick, that was further cut into approximately $\frac{1}{8}$-in. squares. This wafer technique was used on all castings examined. Carbon equivalent was determined as per cent carbon plus $\frac{1}{3}$ per cent silicon.

Regression analyses were performed to determine the relationship of carbon loss to carbon equivalent.

To determine the effect of carbon flotation on carbon distribution in the solidified iron, carbon analyses were also made at various locations in the same casting.

METAL TRANSFER CARBON LOSS

A loss in carbon content of the molten iron occurs in the time interval between silicon inoculation and pouring of the castings, whenever the carbon equivalent immediately after inoculation exceeds 4.77 per cent. Figure 1 shows the relationship of carbon loss during this time interval to carbon equivalent of the iron immediately after inoculation.

When the carbon equivalent of the molten iron immediately after inoculation is above 4.77 per cent, kishing, the precipitation and flotation of graphite, occurs on cooling during the time interval necessary for transferring and pouring. Unfortunately, temperatures were not determined and the 4.77 per cent carbon equivalent is an average representation of the pouring temperature only.

*Max Kuniansky, "Problems in Producing Ductile Iron," AFS TRANSACTIONS, *vol. 58*, p. 707 (1950).

A. H. RAUCH is Mgr., Met. Div., and J. B. PECK and G. F. THOMAS are Met., Materials Engrg. Dept., Deere & Company, Moline, Ill.

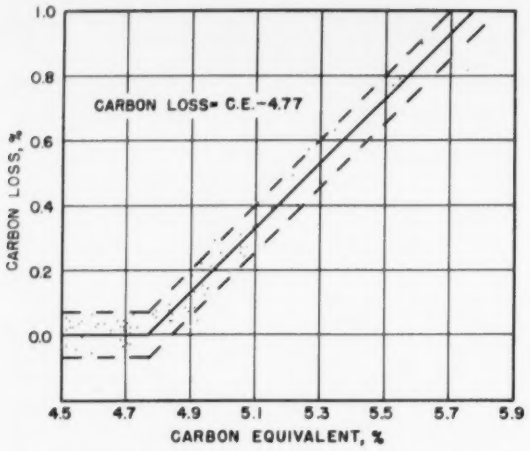


Fig. 1 — Relationship of carbon loss in time interval between inoculation and pouring to carbon equivalent immediately after inoculation with observed data plotted.

CASTING AND SOLIDIFICATION CARBON LOSS

When the carbon equivalent of the molten iron was less than 4.55 per cent, the carbon content of the wafer sample from the bottom inch of the Y block, and the carbon content of the chilled pin, were essentially the same. When the carbon equivalent of the molten iron was above 4.55 per cent, the carbon content of the Y block sample was less than that of the pin. This relationship is shown in Fig. 2.

When the carbon equivalent exceeded 4.55 per cent in the molten iron, flotation or migration of carbon to the cope surface occurred. This was demonstrated by carbon analyses at 1 in. increments from the bottom of the Y block to the top surface, as shown in Table 1.

Carbon flotation manifests itself as a segregation of graphite nodules in a layer at the cope surface in castings of moderate to heavy section size. Figure 3 shows a fractured section of a casting exhibiting carbon flotation, and Fig. 4 is a photomicrograph through the graphite-rich layer. Analyses for the carbon content

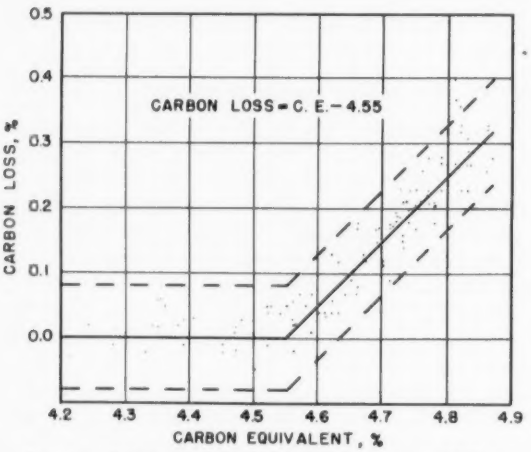


Fig. 2 — Relationship of carbon loss during solidification to carbon equivalent at time of pouring with observed data plotted.

TABLE 1 — CUPOLA PIN, FOUNDRY PIN AND Y-BLOCK CASTINGS CARBON EQUIVALENT COMPARISON

	Sample number							
	1		2		3		4	
Location	T.C., %	C.E., %	T.C., %	C.E., %	T.C., %	C.E., %	T.C., %	C.E., %
Cupola pin	3.76	4.70	3.89	4.80	4.01	4.91	3.41	4.24
Foundry pin	3.78	4.72	3.78	4.69	3.86	4.76	3.48	4.31
Y Block								
Bottom in.	3.59	4.53	3.61	4.52	3.65	4.55	3.39	4.22
2 in. from bottom	3.56		3.60		3.71		3.40	
3 in. from bottom	3.68		3.64		3.55		3.34	
4 in. from bottom	3.63		3.59		3.56		3.37	
5 in. from bottom	4.48		4.85		4.99		3.36	
% Silicon	2.83		2.74		2.70		2.50	

at the cope surface, and below the cope surface, showed that when carbon flotation occurs, the carbon content below the area of flotation yielded a carbon equivalent of 4.55 per cent. Where no flotation occurred, the carbon equivalent was at or below 4.55 per cent throughout the casting. Table 2 shows the analyses of representative castings.

DISCUSSION

The flotation of carbon during the time interval between inoculation and solidification occurs only when the composition is hypereutectic, and can be explained on the basis of the conventional iron-carbon-silicon equilibrium diagram. Figure 5 is a section of the iron-carbon-silicon diagram at 2.0 per cent silicon and 2.0 to 5.0 per cent carbon.* This diagram was originally drawn to illustrate the metastable system. Since the position of the lines are not known with great precision, little inaccuracy will result in adapting this diagram to explain the cooling and solidification of a hypereutectic iron in the stable system.

If the temperature at the time of inoculation is 2500 F, and the carbon content is 4.5 per cent (C.E. = 5.2%), all of the carbon will be in solution, as shown at point A. If, during the time interval necessary to transfer and pour one-half of the ladle, the temperature drops to 2300 F, the composition of the iron will be at point B. The carbon loss will be the horizontal distance between the projection of point A and point B on the abscissa. The equilibrium carbon content at

*Alfred Boyles, *The Structure of Cast Iron*, American Society for Metals, p. 2, (1947). Cleveland.

TABLE 2 — CARBON EQUIVALENT EFFECT ON CARBON FLOTATION OF DUCTILE IRON CASTINGS

	Carbon, %		Carbon Equivalent, %		
Sample	Cope	Drag	Cope	Drag	Silicon, %
1	3.47	3.45	4.47	4.45	2.99
2	3.29	3.29	4.17	4.17	2.65
3	3.47	3.48	4.37	4.38	2.69
4	3.58	3.58	4.49	4.49	2.74
5	4.89	3.51	5.89	4.51	2.99
6	4.39	3.63	5.33	4.57	2.81
7	5.25	3.53	6.22	4.50	2.90
8	8.45	3.53	9.36	4.44	2.74

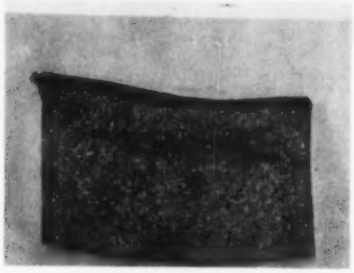


Fig. 3 — Fracture face showing sooty fracture layer resulting from carbon flotation. Dark area at bottom is shear area at fracture origin and not a defect. 1 ×.

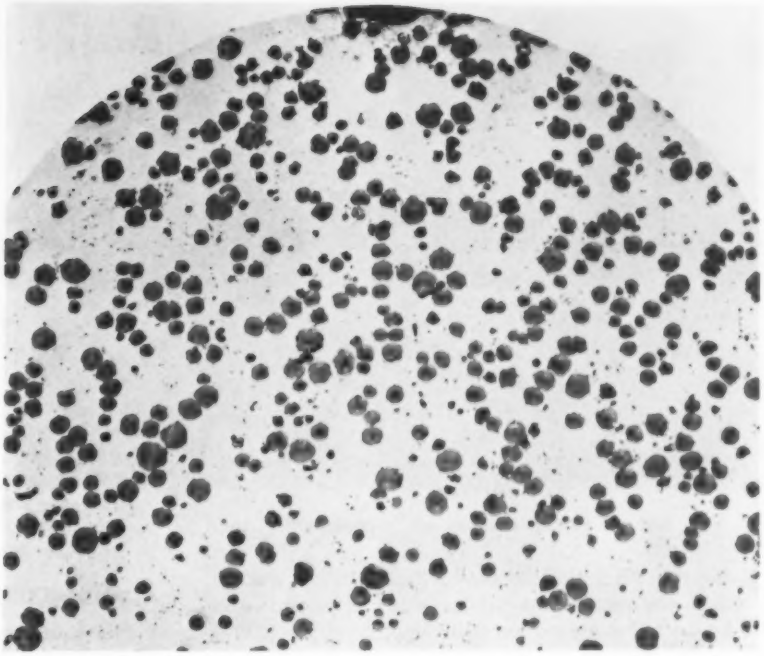


Fig. 4 — Graphite flotation along cope surface of casting (top of photo) shown in Fig. 3. Unetched. 50 ×.

point B is 4.3 per cent (C.E. = 5.0%), therefore the molten iron will have lost 0.2 per cent carbon by kishing. Further carbon precipitation occurs as the temperature of the iron drops to the point where solidification begins, the eutectic temperature shown at point C, where the carbon content is 3.6 per cent (C.E. = 4.3%).

The difference in the carbon content at point B where the mold is poured, and at point C, where solidification begins, is 0.7 per cent. With the density ratio of 3.5 to 1 for iron to graphite, the precipitated graphite rises to the surface of the metal.

The foregoing discussion describes solidification of an iron-carbon-silicon alloy under equilibrium conditions. Ductile iron contains other elements, and does not generally solidify under equilibrium conditions in normal foundry operations. This results in a shift of the phase lines, but should not affect the precipitation and flotation of graphite per se.

The indicated eutectic at a carbon equivalent of 4.55 per cent found in this investigation is probably not the true eutectic point for ductile iron. It may be high due to one of the following conditions:

1) The cooling rate is too rapid for complete carbon precipitation to occur resulting in a supersaturated solution at the eutectic point.
2) As the eutectic starts to form, carbon nodules may be trapped and prevented from floating to the top.

However, the carbon equivalent of 4.55 per cent is a good practical maximum value for moderate section casting if flotation is to be avoided.

This work also indicates that with hypereutectic irons, graphite nodules form in the melt, which is analogous to the formation of kish in hypereutectic flake graphite irons. In the controversy between those who maintain that nodules form in the melt, and those who say nodules form after solidification, frequently no distinction is made between hypereutectic, eutectic and hypoeutectic irons.

Carbon flotation is often confused with another surface defect occasionally found in castings. This condition is commonly called cope defect, and results from a flotation of dross consisting of magnesium sulfides and oxides which have not been cleansed from the metal. Figure 6 is a fractured section through a casting with cope defect, and Fig. 7 is a photomicrograph of the defective area. Dross flotation is dependent upon metal cleanliness, pouring temperature, skimming practice and gating system. Graphite flotation is dependent upon the carbon equivalent in the ladle, pouring temperature and solidification rate.

CONCLUSIONS

1) Kishing, or the precipitation and flotation of car-

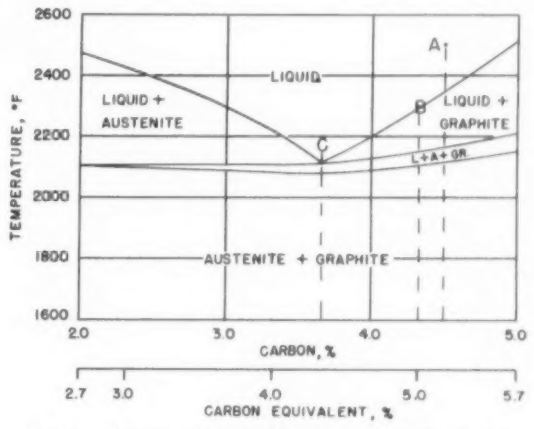


Fig. 5 — Section of iron-carbon-silicon diagram at 2.0 per cent silicon.

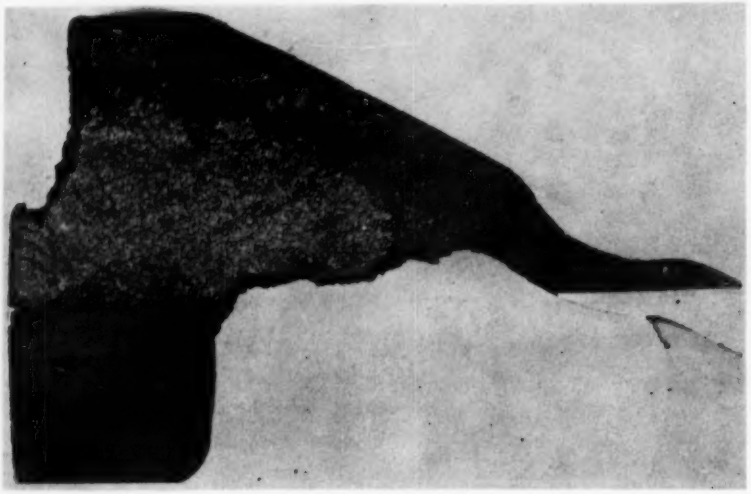


Fig. 6 — Fracture face showing sooty fracture layer resulting from dross and slag flotation. Dark area at bottom of fracture face is shear area at fracture origin and not a defect. 1 ×.

bon, occurs during cooling of hypereutectic ductile iron.

2) During the solidification of hypereutectic ductile iron castings carbon, in excesss of the amount necessary to form a carbon equivalent of 4.55 per cent, is precipitated and floats to the top surface where it is trapped in the solidifying metal.

3) Carbon wafers are a reliable method of sampling ductile iron castings for carbon analysis. The discrepancies in carbon analysis between wafer samples and chilled samples in hypereutectic ductile iron are due to carbon flotation.

ACKNOWLEDGMENT

The authors gratefully acknowledge the cooperation and encouragement of the John Deere Malleable Works, which supplied the castings used in this investigation, and the personnel of the Materials Engrg. Dept., who conducted the chemical analyses and metallurgical examinations.

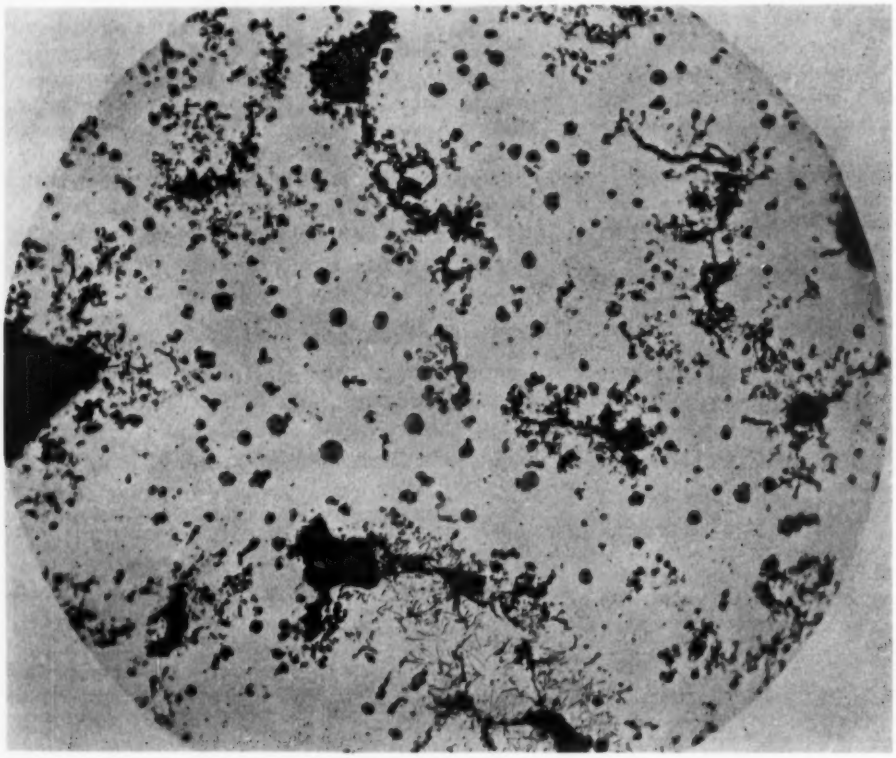


Fig. 7 — Dross and slag flotation in cope defect area in casting shown in Fig. 6. Unetched. 50 ×.

TIMING OF EXPANSION SCAB FORMATION

By J. E. Haller

ABSTRACT

Mold surface penetration was studied to find when expansion scabs occurred. A step casting was designed for making a buckled or expansion scabbed casting. The tests showed that one type of scabs and/or buckles occurred because of sand expansion, and occurred at the time the mold was filling, or while the metal was still in a liquid state.

INTRODUCTION

This investigation was initiated to study mold surface penetration using the theory of exudation of metals during solidification as its basis.* The reference author hypothesizes that the occurrence time of expansion-type scabs is most important, and suggests that the name of this defect be changed to "exudate scab" so it will be differentiated from the errosion-type scabs.

On the basis of this investigation this author disagrees with the reference author. It is stated in the article:

> "From several molds where it is known that the mold cavity has been filled with metal and, subsequently, a run-out has occurred leaving a shell, an expansion scab has never been observed on a casting. This observation leads one to question the commonly-accepted thinking that these scabs form as soon as the mold is filled. Further, many bleeding tests have been conducted and reported in the literature and no mention has been found concerning scabs, penetration or veining being present on such castings."

PROCEDURE

A step casting, as shown in Fig. 1, was designed for these tests to promote a buckled or expansion scabbed casting. The gating used had a basin under the sprue with a single, short ingate into the thickest part of the casting. The gate was $\frac{3}{16}$-in. x $\frac{3}{4}$-in., or 0.14 in.^{2} in area. The actual pouring time for this casting was 18 sec, although normal pouring time would have been 13.8 sec for a gray iron casting weighing 23 lb with an average thickness of $1\frac{1}{4}$ in. A choke ingate was used with runner and ingate in one, as shown in Fig. 2.

Misruns, rattails and expansion scabs and/or buckles may occur from pouring a casting too slowly, according to the author's experience. The theory is that the slower the pour, the more radiant and convection heating can take place on the surfaces of the mold not yet covered by metal. These uncovered surfaces are unlike those immediately covered by metal in that they are somewhat dried.

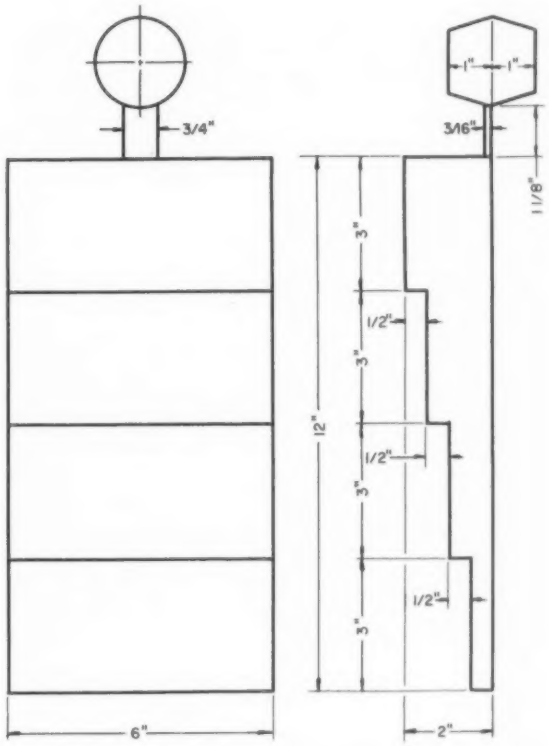


Fig. 1 — Drawing of step casting designed to make a buckled or expansion scabbed casting easily.

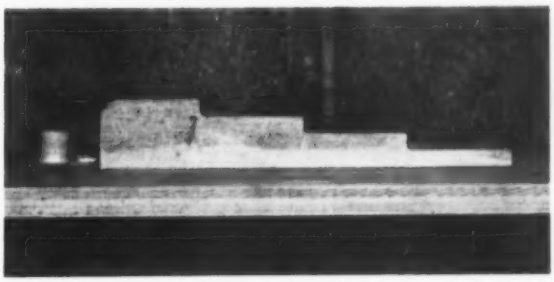


Fig. 2 — A choke ingate was used, the runner and ingate all in one.

*D. C. Williams, "Another Look at Expansion-Type Scabs," *Foundry Trade Journal*, Feb. 17, 1955.

J. E. HALLER is Asst. Supt., James B. Clow & Sons, Inc., Coshocton, Ohio.

TABLE 1 — SAND ANALYSIS

Property	Amount
Moisture,%	7.3
Green Permeability	38
Green Compression	10.2
Green Shear	2.8
Dry Compression	158
Deformation	0.033
Toughness No.	337
Flowability	68
Sample Hardness (2 x 2)	80
Sample Hardness (2 x 1⅛)	89
Hot Strength	212
Combustible,%	6.40
Density (2 x 1⅛) g.	56.5
Density (2 x 2) g.	167.0

Retained on Screen,%

Screen	%	Screen	%
6	0	100	27.0
12	0	140	13.6
20	T	200	6.4
30	0.4	270	2.2
40	2.0	Pan	2.2
50	11.2	AFS Clay	10.0
70	27.2	Gfn	70.9

TABLE 2 — METAL ANALYSIS

Composition,%	
Si	1.79
C	3.28
S	0.055
Mn	0.39
P	0.59
Eutectic,%	—0.20

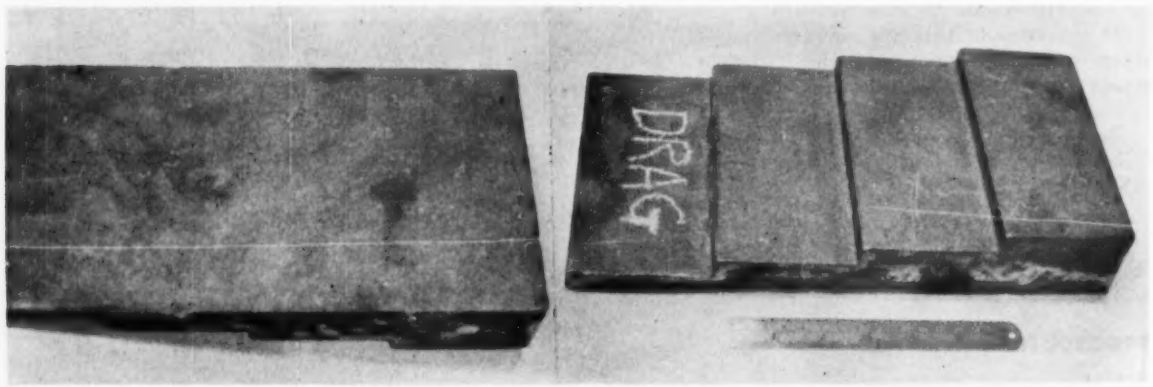
The gate used for this casting gave a squirting action to the metal. This action, and the way the mold filled when all of the casting was produced in the drag, caused buckles and scabs on the drag surfaces of the casting. No scabs or buckles appeared on the ½-in. step farthest from the gate at an elevation that filled last. Perhaps this was due to using sand with higher moisture content than optimum.

Pouring a casting too slowly, especially with a single ingate, subjects the path of the metal to a higher temperature than is in the remainder of the mold, because it is in contact with entrance metal during the full time the mold is being poured.

For this test, the first casting was made from a matchplate using a jolt squeeze machine. The sand used contained more than the normal amount of moisture. A typical analysis of the sand and metal is shown in Tables 1 and 2. There were no buckles or scabs on the casting, as shown in Figs. 3a and 3b.

Since this casting did not show the expected defects, it was decided to over-ram the mold with an air rammer. This resulted in the iron blowing out of the mold, as the mold was so hard and wet.

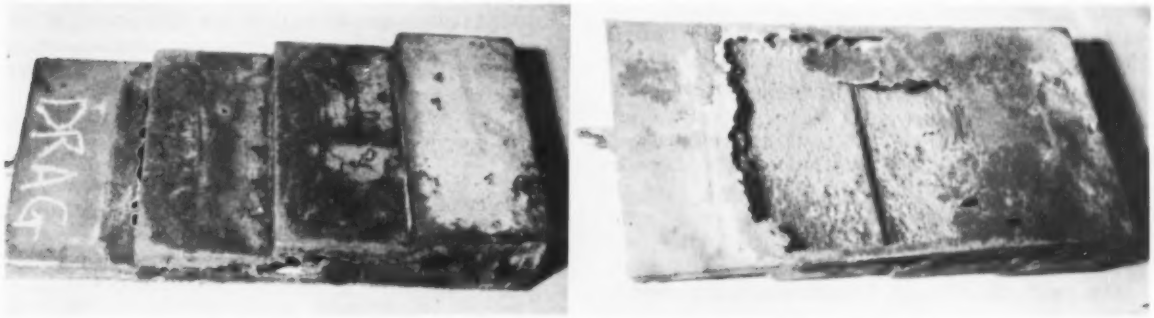
Casting 4 was made entirely in the cope of the mold. The average mold hardness was 90. In Fig. 4a, a shrink or draw can be seen, caused by low ferrostatic pressure with some exudation at the shrink cavity. The drag section of this casting is shown in Fig. 4b. Two buckles and a rattail are on this section.



Figs. 3a (left) and 3b (right) — The casting made from a matchplate using a jolt squeeze machine, with sand containing more than normal moisture did not buckle or scab.

Figs. 4a (left) and 4b (right) — There was a shrink or draw because of low ferrostatic pressure with some exudation at the shrink cavity and adjacent to it in casting no. 4. Fig. 4b—Drag section of casting in Fig. 4a.

Figs. 5a (left) and 5b (right) — Casting no. 5 was made in the same manner as casting no. 4, except that it was made in the drag. Scabs occurred on every step except the ½-in. thick step farthest away from the gate.



Figs. 6a (left) and 6b (right) — Casting no. 6 was poured out the gate 12 sec after the mold was filled. The casting is without expansion defects except on the cope molded section. There is a well-defined buckle entirely across the casting at the ½-in. section.

Casting 5 was made in the same manner as casting 4, except that it was made entirely in the drag section of the mold. Iron from the same ladle was used to pour this casting. Scabs occurred on every step except the ½-in. thick step farthest from the gate, as shown in Figs. 5a and 5b. The flat cope in Fig. 5a shows the surface defects caused by the buckled sand in the drag that floated to the cope before solidification took place. From this it can be seen that the buckles in the drag had to take place before the mold was completely filled, or at the time of filling, and when the iron in the second, third and fourth steps was liquid.

Pour-Out Castings

A series of pour-out casting was made from molds following the procedure previously described. Casting 6 (Figs. 6a and 6b) was poured out of the gate 12 sec after the mold was filled. The casting had no expansion defects, except in the cope. At the ½-in. thick section there was a well-defined buckle entirely across the casting.

None of the pour-out castings was strong enough to withstand shot blasting. Discolored sections seen in Figs. 6a and 6b are adhering sand.

Another of the pour-out castings is shown in Fig. 7. This casting was poured out the gate in 15 sec. Two buckles or scabs can be seen on the third step, and one small buckle on the side at the beginning of the top step.

These buckles (Fig. 7) could not have formed from solidification pressure of the iron as it goes through its graphitization period, or from atmospheric pressure at a hot spot, because only a thin shell of iron formed in the specified time.

Additional pour-out castings were made using the same ramming techniques, varying the pouring temperature and pour-out times, in an attempt to obtain a minimum thickness complete casting shell. This was not accomplished. However, Fig. 8, showing a

Fig. 7 — The metal was poured out of the gate in 15 sec. Note two buckles or scabs on the third step, and one small buckle on the side of the top step.

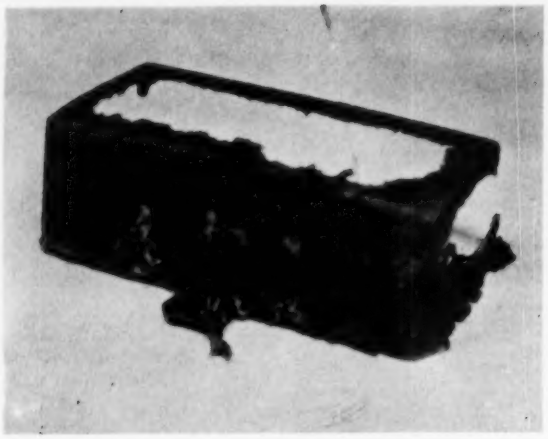


Fig. 8 — A buckle can be seen on the back next to the gate entrance. This casting was poured out so soon that only an outline of the shape is left.

part of a casting, has a buckle on the back next to the gate entrance. This casting was poured out in such a short length of time that only an outline of the shape formed.

Figure 9 shows the pour-out casting where the mold was broken in lifting and pouring out. This caused a fin at the joint of the cope and drag. Note the small buckle on the third step.

CONCLUSIONS

Hot spots alone cannot be considered the cause of expansion-type scabs. It is well known that flat copes, last to contact the molten iron, are more prone to expansion-type scabs than other parts of the mold. If hot spots or hot areas in the mold and casting were the sole cause, every casting would have these defects at the mold gate.

It is possible that the original hypothesis of this investigation is more applicable to penetration than to buckling or scabbing. The fact that a scab in a

Fig. 9 — This pour-out casting is one where the mold was broken in lifting and pouring out. This caused a fin at the joint of the cope and drag. A small buckle is on the third step.

sand mold, or an exudation from the top of the downgate on a permanent mold, has different percentages of element composition than the base metal is recognized. Literature has pointed out that at various solidification temperatures varying amounts of the elements are combined.

It is well known that to obtain representative samples of any complex material such as cast iron, drillings must be taken through a full section to overcome errors incident to a partial section sample. This is because of the elements and percentages that combine at various temperatures and times under certain conditions.

In any event, these tests show that one type of scabs and/or buckles is a function of sand expansion, and the occurrence time is as the mold is filling or while the metal is still liquid.

There is nothing a foundryman can do to alter the solidification combination of elements. However, he can control the solidification rate toward the desired characteristics of the metal and casting by ramming, chills, grain fineness, etc.

RADIOISOTOPES UTILIZATION IN THE FOUNDRY INDUSTRY

By M. Pobereskin and D. N. Sunderman

ABSTRACT

The application of radioisotopes is saving American industry 500 millions of dollars each year at the present time. This saving is made with only 0.3 per cent of our industrial concerns using radioisotopes. On this basis a reasonable potential savings would be on the order of 50 billions of dollars per year.

Applications of radioisotopes in the metals industry, while relatively few in number, have contributed measurably to an improved product and a better understanding of the processes involved. These applications include measurement of wear of cutting tools, bearings and refractory surfaces, tracing of chemical and physical species through complex processes, measurement of thickness of solid and fluid metal and surface coatings, corrosion, location of alloying elements in microstructure and the diffusion of metals in alloys.

While the Atomic Energy Commission Office of Isotopes Development is engaged in an extensive program of encouraging further applications, the major barrier to such work is the lack of communication between the scientists in the metal industry who have the problems, and the scientists in the radioisotope laboratories who have the techniques with which to solve them. Widespread uses of radioisotopes in the metals industry do not require new techniques, but only the application of already developed techniques to new problems.

INTRODUCTION

A recent survey by the United States Atomic Energy Commission indicated that industry in this country saves about 500 millions of dollars annually through the application of radioisotopes and their radiations. This remarkable statistic is made even more remarkable when one considers that only about 0.3 per cent of our industrial concerns are using radioisotopes in some fashion. Consider further that a major part of the above savings are being made in the petroleum industry, and in applications involving thickness gaging and control of sheet materials.

Since potential production savings through application of radioisotopes may be estimated at 100 times the above figure, the question naturally arises, "Why are not the applications more widespread than indicated?" We shall consider in part the answering of the above question, and further to providing examples of radioisotope applications that have been made and that may be made in the metals industries.

The factors which have affected the rate of application of radioisotopes in industry are undoubtedly fairly complex, and beyond the scope of this paper to analyze in detail. Lack of familiarity with properties of radioisotopes, exaggerated hazards and costs, restrictive regulations governing use, etc., have all been considered as retarding factors in the application of radioisotopes. The authors feel that another factor, usually ignored, is that present-day radioisotope applications are generally considered completely divorced from their historic background and development.

One could easily form the impression from reading current literature that radioisotope applications were born full grown from the release of atomic energy. While it is true that the broad scope of modern radioisotope applications stem from the atomic energy development, in actuality the release of atomic energy resulted from the study of the nucleus which was sparked by the discovery of radioactivity, and the natural radioisotopes. These studies originated at the end of 19th century with Becquerel's discovery of the radioactivity of uranium, and the Curies' discovery of radium and many of the other natural radioisotopes.

In the first third of this century, many scientists, working with natural radioisotopes carried out fundamental studies in such fields as self-diffusion, crystal growth, solubility, tracer reactions and determination of the age of the earth. Many of these investigations still stand as models in their field, and they provide the fundamental basis for continuing studies to this date. Soon after natural radioisotopes were discovered and some of their properties understood, applications of industrial importance were made.

Early Radioisotope Uses

Everyone was familiar, long before the discovery of nuclear fission, with the use of radioisotopes in producing self-luminescent phosphorus, static electricity eliminators and radiation therapy sources. Such applications, albeit with improvements based upon broader knowledge, are still being made today. It is in this context that present-day radioisotope applications must be considered as being directly derived from, and owing much to the studies of the early workers with radioisotopes.

Based on this background, the aura of awe surrounding radioisotope applications and based on its relationship with nuclear fission can be eliminated. From this viewpoint this relationship falls into its proper perspective; namely, that we are able to produce in nuclear reactors large quantities of radioiso-

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topes of all elements in the periodic table, including many which had never been found in nature. It is this capability which has added a new dimension to the use of radioisotopes.

RADIOISOTOPE APPLICATIONS

Before considering some of the applications of radioisotopes which are of particular interest to the metals industries, let us review the characteristics which make radioisotopes such powerful tools. From the viewpoint of their use as tracers, the basic factor is that radioisotopes exhibit the chemical and physical properties of the elemental species to which they belong. They may be identified, however, in the presence of large amounts of the nonradioactive isotopes, by virtue of the radiations which they emit.

Moreover, each radioisotope[1] may be specifically identified by virtue of the specific type of radiation which it emits, by the energy of this radiation and by its half life (the period during which the radiation intensity is reduced to half its value). All these properties relating to energy may be readily and precisely measured.

Many of the rewarding industrial applications of radioisotopes to date, are based upon the effects matter has on radiation, namely, matter absorbs, scatters and moderates radiation in a manner which depends on the nature of the material and the radiation. These effects have become the basis for a large number of devices for measuring properties of and controlling the production of a wide variety of materials.*

Wear

The problem of metals wear is important to our economy generally, and to the foundry industry in particular. On the one hand the foundry must produce tool steels which wear as little as possible, and on the other hand it must produce metals for fabrication which are readily machinable. From the viewpoint of end use it usually is desirable for the final components to be resistant to wear, also. Application of radioisotopes to study of the metallurgical factors which affect wear is, therefore, of considerable interest.

In measuring wear with radioactive tracers, it is first necessary to incorporate radioactive material in the part whose wear is to be measured. This may be accomplished most simply by placing the part in the neutron field of a nuclear reactor. For an iron part, the radioactivity induced by such irradiation is due to the iron atoms themselves, so that the part has undergone no physical change during irradiation. If it is not possible to irradiate the entire part, radioactive material may be placed on its surface by electrodeposition or vapor deposition. Radioactive metal inserts are sometimes placed at the points where wear measurement is desired.

Wear Test Advantages

The primary advantages of radioactive wear testing methods are high sensitivity, rapidity and ease of operation. The sensitivity is sufficiently high that 10^{-8} grams of wear material are frequently measurable. Other methods based upon weighing or chemical analyses cannot compete either in sensitivity or with regard to rapidity and ease of operation. Moreover, radioactive wear measurements can generally be performed without disassembly of the machine, and may frequently be made automatic with wear results recorded continuously.

Several examples will illustrate the versatility of the technique. Tool bit wear, or machinability tests, can be made by irradiating the tool bit in a reactor for several weeks (Fig. 1). Following irradiation, the "specific activity" of the bit is determined to obtain a precise correlation between radioactivity and weight of tool bit. The radioactive bit is then placed in the lathe or other cutting tool, and chips taken from the stock during machining are radioassayed. The radioactivity of the chips is directly proportional to weight of tool bit worn from the cutting edge.

Bearing wear is similarly easy to measure. The wear part is made radioactive by one of the previous techniques. It is run in a system where the lubricant can be collected and radioassayed either continuously or periodically. The radioactivity of the lubricant is a measure of the wear of the bearing.

Similar procedures are used routinely to determine the quality of lubricating oil in internal combustion engines (Fig. 2). Piston rings are irradiated, and the radioactivity of the oil measured as a function of type of lubricant, type of fuel, water temperature, load and other engine variables.

The application of radioactivity to wear measurement from a somewhat different angle has been reported by Russian and English investigators who determined the rate of wear of a refractory liner in a

*M. T. Simnad, "Review of Metallurgical Applications," *International Journal of Applied Radiation and Isotopes, vol. 1*, no. 3, Nov., 1956.

*"Applications of Radioactive Isotopes and Fission Products in Research and Industry," *Proceedings of the Geneva Conference on Peaceful Uses of Atomic Energy, vol. 15*, United Nations, New York, 1955.

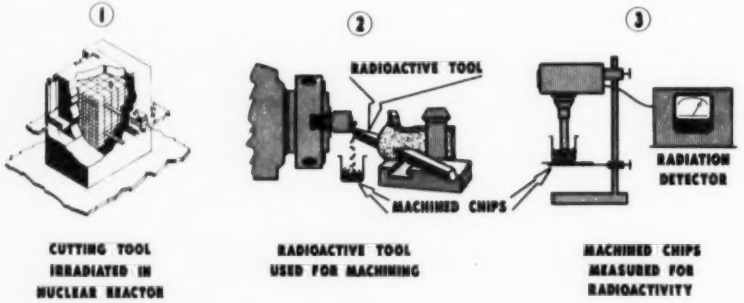

Fig. 1 — Measurement of cutting tool wear and life by radioactivity tests.

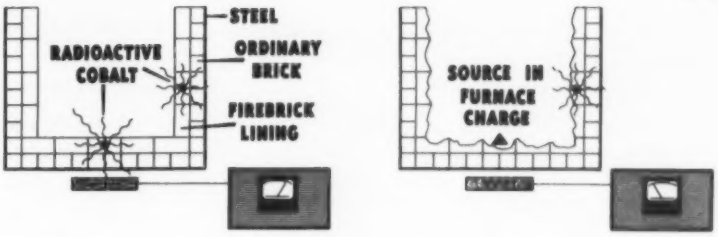

Fig. 3 — Measuring wear of firebrick lining using radioactive cobalt.

blast furnace (Fig. 3). Capsules containing the radioisotope cobalt-60 are placed at different distances from the internal surface of the refractory. Their presence is noted by measuring the radiation outside the furnace opposite the radioactive source. When the refractory liner is worn away to the extent that the capsule is exposed to the molten metal, the source dissolves in the metal.

The disappearance of the radiation source is detected by the measuring the decrease in radiation level outside the furnace. By placing several such sources at different distances from the inside surface, the rate of wear can be determined, and measures taken to replace the liner before damage is done to the shell. The cobalt-60 dissolved in the melt becomes so dilute that there is no hazard in use of the metal. This type of radioisotope application may serve as a form of process control, helping to prevent accidents and reducing the idling of equipment and pig iron loss.

Chemical and Physical Tracing

In the application of radioactive materials to chemical and physical tracing, the techniques are chosen to suit the particular problem. A description of several applications, however, will serve to elucidate the more generally used techniques.

The vapor pressure of metals has been studied extensively with the help of radioactive tracers. In general, the vapor pressure of a metal system, because it is so low, is difficult to measure by other techniques, but by the use of radioactive tracers detection is simple and sensitivity of measurement is increased. Tracers have been used in pure metal and alloy systems up to 2000 C. The common technique is to heat the radioactive metal in a vessel with a small orifice above the liquid level (Fig. 4).

A cold surface is placed above this orifice and the condensed metal atoms measured by determining their radioactivity. Vapor pressure measurements of this type furnish information on metal activity versus concentration in alloys, and the extent of formation of compounds of metal and nonmetals such as silicon, sulfur and phosphorus.

Radioactive tracers can also furnish information on the rate of desulfurization and dephosphorization of metal in contact with slag. Tracers of sulfur or phosphorus added to the metal before slagging will distribute themselves between the metal and slag phases in the same ratio as the nonradioactive sulfur or phosphorus. By taking samples of slag at various times the rate of removal of these elements from the metal can be determined. The effect on this rate of the presence of other metal salts in the slag can be evaluated and the optimum system chosen.

The rate of mixing and melting in furnaces can be studied with radioactive tracers. It was found, for example, that ferro-chrome added to a 190-ton open hearth furnace, melted in 10 to 20 min and was by this time distributed uniformly through the melt. In these studies radioactive ferro-chrome was added to the furnace and small samples taken periodically. Measurement of the radioactivity of these samples indicated when the entire addition had melted and when it became uniformly distributed in the melt.

Mixing Rate Determination

Mixing rates in a steel bath during decarburization were also determined in this manner. When such mixing rates are accurately known it is frequently possible to reduce the residence time in the furnace and increase utilization of equipment.

The source of sulfur in open hearth furnaces was determined by use of radioactive tracers. Radioactive sulfur added to the fuel gas was traced by its radioactivity into the melt and its concentration measured as a function of time. It was found that 10 to 20 per cent of the sulfur in the fuel gas was transferred to the melt during the melting period, while

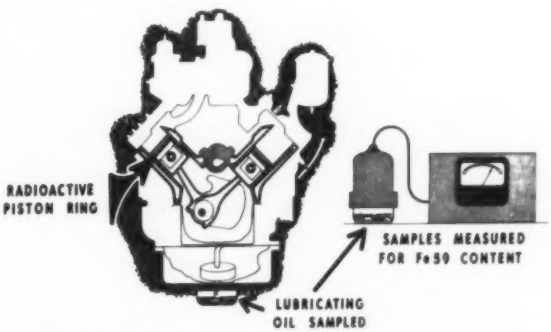

Fig. 2 — Radioactive iron for friction and lubrication studies.

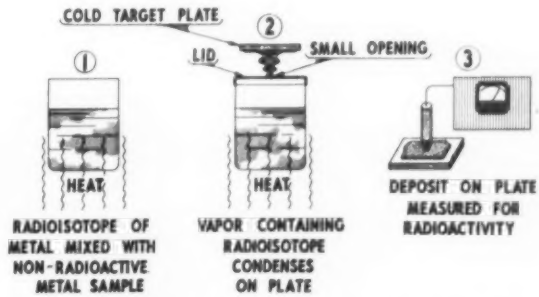

Fig. 4 — Radioactive isotopes for measuring vapor pressure of metals.

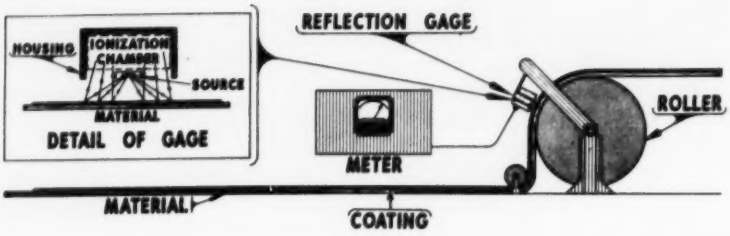

Fig. 5 — Radioactive source of backscattering thickness gage.

only 1 per cent was transferred during the subsequent refining period.

Sources of nonmetallic inclusions in steel may be identified by use of tracers. Radioactivity added to slag, ladle brick and refractory lining was traced to the finished metal part and the source identified. It was found in one case that modifications in the methods of deoxidation and pouring reduced the quantity of inclusions and hence the amount of waste.

The volume of metal in a furnace can also be determined by tracer techniques. A known quantity of radioactive material is added to an unknown volume of metal. When thoroughly mixed, the metal volume may be calculated from the degree of dilution of the tracer.

The kinetics of crystallization of steel has been studied with radioactive tracers. Previously used methods based upon pouring the uncrystallized metal from the mold after a known period of cooling were found inaccurate, since pouring tended to break off dendrites that extended into the melt. In the radiotracer method, a small quantity of radioactive metal was added to the mold at various times during solidification. Sectioning the solid metal followed by autoradiography on a cross-section showed the extent of crystallization at the time of each addition of tracer.

Thickness Gages

The application of radioisotopes to the measurement of thickness is probably the most extensively applied of any radioisotope technique. The general technique is to place the radioisotope source adjacent to the metal material whose thickness is to be measured. The radiation from the radioisotope source is attenuated by its passage through the metal. The intensity of this transmitted radiation is a function of the thickness of the metal and its density. The output signal from a radiation detector on the opposite side of the metal from the source can be calibrated to read directly in thickness.

As an alternative, the fraction of the radiation from the source which is scattered by interaction with the metal may be measured by a detector on the same side of the metal as the source (Fig. 5). In this case, no apparatus need be placed on the opposite side of the material since this may be difficult to accomplish as in the case of a pipe or closed vessel.

The type of radioactive material used in the source is determined by the material whose thickness is to be measured. Beta particle emitters are used for plastics or thin metal films, while gamma ray emitters are used for heavier metal forms. Alpha particle emitters may also be used for thin films. The energy of the beta particle or gamma ray emission must also be selected to obtain the highest sensitivity in the thickness range of interest. As a rough rule of thumb, alpha particle emitters are useful up to about 1 mil of aluminum, beta particle emitters up to about 0.2 in. of aluminum and gamma ray emitters up to several inches of steel.

As examples of the utility of this technique, hot and cold rolled metal strips of 2 in. of iron and 3 in. of aluminum may be measured to 2 per cent accuracy. Wall thickness of tubes or enclosed tanks of up to 1 in. of steel have been measured to 4 per cent accuracy using a backscatter technique. Coatings of metal on metal can be measured by the backscatter technique, if the coating differs in atomic weight from the base. Examples are tin and cadmium on iron which are readily measured in the 0.75 to 0.05 micron range.

The radiation detector output signal can be calibrated in terms of thickness, and used to control the metal-forming process. In such situations, it has been observed that the control is much better than with conventional methods and waste is considerably reduced. Results of radioisotope gaging control of a tandem cold roll mill are shown in terms of the precision with which the thickness of the stock was controlled on the 95 per cent confidence level:

Conventional control	± 10%
Isotope gage with manual control	± 7%
Isotope gage with automatic control	±1.5%

While the uses of radioisotope gaging continue to be increased, the ultimate applicability of this technique has not yet been tapped.

Miscellaneous Tracer Applications

A wide variety of tracer techniques have some applicability to foundry practice, and these will be reviewed briefly here.

Surface reactions, which are of importance in electroplating, pickling, phosphating and sand blasting, have been studied with radioactive tracers (Fig. 6). The general technique is to add radioactive tracer to the solution or solid surface and to measure changes in its concentration or location following various surface treatments. For example, it may be desirable to remove a phosphate coating prior to the application of paint.

By adding phosphorus-32 to the phosphating bath it was possible to incorporate this radioactive tracer into the residual phosphate on the metal surface. Various methods were then tried for removal of this phosphate while determining the extent of removal by measuring the radioactivity of the surface. It was found that an alkaline solution treatment was effi-

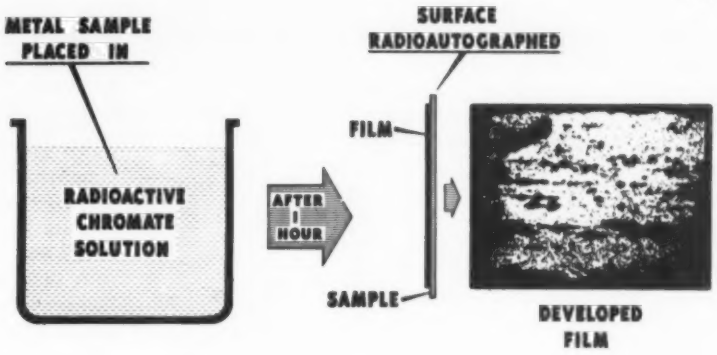

Fig. 6 — Study of mechanism of chromate induced passivity.

cient in removing this phosphate, while sand blasting allowed much of it to remain.

The study of low rates of corrosion has been aided by use of tracers. If the metal is made radioactive and contacted with the corroding solution, the rate of increase of radioactivity in the solution is a sensitive measure of corrosion. In many cases the identity of the corroded specie can be determined simply by instrumental counting techniques without any chemical separation or treatment.

The location of alloying elements in the microstructure of metals has received extensive study with radioisotopes. In this case the alloying element is made radioactive before addition to the melt. The alloy may be cast and forming operations carried out, if desired. Metallographic specimens can be autoradiographed, and the autoradiograph superimposed on the photomicrograph. The first will show only the location of the radioactive element, and the photomicrograph will show its relation to the microstructure. Examples of these techniques include the study of rare earth additions to stainless steel.

In this case, it was found that the rare earths segregated at the grain boundaries, which was the reason for increased machinability. Segregation in lead-bismuth alloys was also studied, and found to be either of the crystal boundary or surface type depending upon the speed of solidification under conditions in linear growth. Tin in bronze, silver in tin, bismuth in copper and aluminum in copper are other systems studied in this manner. Diffusion of metals may be studied in a similar manner by the use of radioactive tracers to determine atomic placement and mobility (Fig. 7).

RADIOISOTOPES FUTURE APPLICATIONS

The expansion of radioisotope uses since 1945, and also future applications, will be based upon the wide variety of isotopic tracers which are available. If one lists all the elements for which radioactive isotopes are available for tracers they may be grouped roughly into three categories. The first group consists of those elements having radioactive isotopes well suited to tracer studies based upon considerations of half-life, radiation characteristics and radiological hazard.

The second group consists of those elements which are more difficult to use as tracers and the third group, those elements which because of short tracer half-life or high radiological hazard should be used only under closely controlled conditions or for short periods of time. These groups are presented in the Table.

Many excellent applications for radioactive tracers are not made because of the lack of communication between those who have the problems and those who have the technique for their solution. Problems which were discussed in the previous section may suggest applications of a similar nature to scientists in other fields. Also, the elements listed in the Table as having suitable isotopes for tracer studies may suggest uses of tracers which have not yet been studied. To overcome this difficulty in communication, the Office of Isotopes Development of the United States Atomic Energy Commission has initiated a long-range

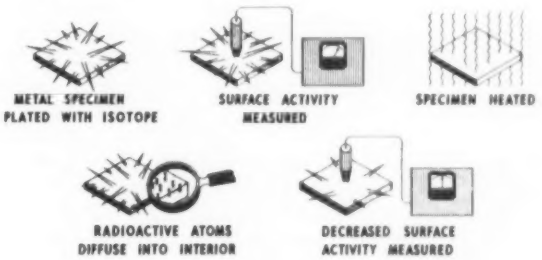

Fig. 7 — Radioactive isotopes for studying solid diffusion.

TABLE — ELEMENTS WHOSE ISOTOPES ARE USEFUL IN RADIOTRACER STUDIES

Group 1. Best Characteristics as Tracer			
sodium	yttrium	cesium	hafnium
scandium	zirconium	cerium	tantalum
chromium	niobium	praseodymium	tungsten
manganese	technetium	samarium	osmium
iron	ruthenium	europium	iridium
cobalt	silver	gadolinium	mercury
zinc	antimony	terbium	thallium
selenium	tellurium	erbium	lead
krypton	iodine	thulium	
rubidium	xenon	lutecium	
Group 2. Average Characteristics			
hydrogen	nickel	rhodium	ytterbium
carbon	copper	palladium	rhenium
phosphorus	gallium	cadmium	platinum
sulfur	germanium	indium	gold
chlorine	arsenic	tin	bismuth
argon	bromine	barium	thorium
potassium	strontium	lanthanum	uranium
calcium	molybdenum	holmium	
Group 3. Difficult to Use			
magnesium	aluminum	polonium	radium

program to encourage the application of radioisotopes to industrial problems.

Organizations having experience in radioisotope research are encouraged to request government funds for the development of tracer applications. Many organizations have already done this and are now working on entirely new and novel applications which will contribute significantly to industrial processes. Some of these studies are short-range programs to develop new instruments utilizing radioactive materials for liquid level gages and density measuring devices. Others are broad surveys to determine the industrial potential for isotope utilization as radiation sources and tracers.

One study which has the potential for wide applicability in industry is determining the feasibility of intrinsic radioactive tracers for industrial process control. An intrinsic tracer is one which is added to the material being processed. Process control would be based upon measurement of the concentration of this radioactive tracer (i.e. specific activity) in the process material. An example of such a system might be the addition of a radioactive isotope of an impurity to iron ore before smelting. A measurement of the radioactivity of the iron would then be substituted for chemical analysis for this constitutent.

Another application would be to tag a particular batch of ore when loaded into the smelter. At the time when melting is complete, and the tagged batch flows from the furnace, a measurement of its radioactivity will serve to differentiate it from the previous batch and the one following it. This type of application may simplify industrial process control of the future, lowering costs and improving the quality of the product.

It is really a misnomer to refer to the above as applications of the future. The isotopes are available now. So are the techniques for handling them and measuring their radiations. What is necessary is that the technologists engaged in the production processes discuss their problems with the scientists trained in tracer techniques. Through this exchange of knowledge between the respective fields, the full potential of this technique can be realized to the benefit of American industry.

PROFIT MANAGEMENT THROUGH COST CONTROL

By R. B. Hill

ABSTRACT

Profits can and should be planned for. If the plan is to be realized, manufacturing costs must be controlled. Cost control is a frame of mind; to be successful it must have top management support. The various specialized techniques for the collection and reporting of costs are important, but really worth-while results can never be obtained until profit-mindedness and cost-consciousness are created in the minds of all company personnel. Then, it is truly possible to obtain the management of profits through cost control.

INTRODUCTION

Profits do not just happen, they must be produced. It is the basic task of management to produce a profit representing a fair return on capital invested.

Profit management means the formulation of a plan resulting in a net profit. If the profit objective is to be realized, control must be exercised to ensure that the plan is adhered to closely.

A major portion of the overall plan for profit must be a plan for manufacturing. When the details are expressed in dollars, they become a manufacturing costs plan. It is only through the control of these costs that the profit goal can be attained.

Webster's dictionary states that "*control* is to exercise a directing influence over." This definition places the responsibility for cost control with management. Cost control is an integral part of management, and must be recognized as a regular part of management's job, not as a special project. When written job descriptions are prepared cost control should be included as a specific responsibility of management at all levels.

TOP MANAGEMENT MUST LEAD THE WAY

How does a foundry get started on a cost reduction program? To be a success, a top management decision to embark upon such a program must come first. This is because the program must have the support of the entire organization, and because it will involve some additional expense particularly in the early stages. It is management's job to see that all levels in the company are sold on the benefits to be obtained from the cost control program.

Cost control is an attitude, a frame of mind, and management must strive to develop a cost-conscious attitude throughout the company. It must be truly sincere in its belief in the value of such a program, for if it is not supervisors and foremen will surely sense it and the program will fall apart.

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COSTS CONTROL

There are generally considered to be three main categories of manufacturing costs: 1) direct labor, 2) direct material and 3) overhead.

Direct Labor

There are many text book definitions of direct labor. The definition the author likes is: All labor that can be practicably charged to an individual job should be classified and collected as direct labor. What is practicable to pick up as direct labor will vary from plant to plant, dependent upon the type of operation, its size and the technique or system of labor distribution employed.

One of the primary reasons for collecting labor cost information is for use of the control of direct labor cost on individual jobs. In order to exercise any effective control over this cost, the first step must be to predetermine the amount of time a direct labor operation such as molding should take for a particular casting. This predetermined time can be arrived at in a number of different ways.

The simplest method, and the minimum that should be employed by the smallest foundry, is an estimate of direct labor time by the foreman for each of the direct labor operations such as molding and coremaking. A small, simple job cost card should be used by the foreman when preparing his estimate. Filling out the card ensures a systematic approach to the estimate, and reduces the otherwise strong possibility of overlooking some necessary element of direct labor cost.

When overhead has been applied as a percentage of direct labor, metal cost added, plus an overall allowance for scrap, a cost estimate that can be used by the sales department in establishing the casting price is the result. This is the first use to which management usually puts the predetermination of direct labor costs, and it is an important one. In effect, when a mark-up has been assigned to arrive at a selling price, the development of a profit plan has been extended down to an individual job.

All too many foundries stop at the preparation of this job plan, without taking sufficient steps to exercise control which will enable the profit plan to be realized. In its simplest form, the steps that can and should be undertaken are to advise the direct laborer and his supervisor of the time allowed for in the es-

timate for the job. The work assignment is then known before the job begins, which gives the direct laborer and supervisor a chance to make the plan workable.

After the first one or two castings have been produced on a new job, the actual time on the job should be checked with the estimate. If the actual has exceeded the estimated time, the job should be studied to see if the pace or method can be improved to a point where cost can be reduced sufficiently to recoup on the remainder of the order. This is an extremely simple system, and one which will exercise a significant degree of control at a low expenditure for the small shop. Its greatest weakness lies in the quality of the informal estimate, which is prepared by the man against whose performance it is to be used as a measuring stick.

Foundry Estimator

To partially overcome this objection, and to enable the handling of a greatest volume of estimates in the larger sized shop, a foundry estimator is appointed. Typically, the estimates are now a compromise between the estimator and the foreman, if the estimator is a man of considerable shop experience. Otherwise, he simply becomes a clerk who enables a larger volume of estimates to be processed.

If the estimator is a man experienced in foundry estimating, and with a thorough knowledge of a particular foundry, the estimated times attain sufficient accuracy to begin the exercise of a more complete type of direct labor cost control.

On the day following the production being considered, a daily report can be prepared for each separate area for which a supervisor is responsible. This report should list the molder's name, the pattern number, the number of pieces produced, the estimated time per piece, the total estimated time for all the pieces produced from that particular pattern, the total actual direct labor time charged for the job and the variance of actual from the estimated time. This is a simple report that can be prepared by the timekeeper. It should deal in man-hours only.

This daily report highlights the individual jobs which actually exceeded estimated time, and which, therefore, need individual attention. If the estimated times for all the jobs and actual times reported are totalled, it enables the company to calculate a percentage of direct labor efficiency for the particular department. This procedure is inevitably rewarded by an increase in effort by the supervisors to improve and then maintain their level of efficiency.

The greater the accuracy of the estimated direct labor time, the more effectively they can be used by management for cost control purposes. The next increase in the degree of control that is possible to exercise over direct labor costs results from the use of measured day work. Measured day work is the term used to describe the direct labor control system, whereby engineered time standards are established and used to predict the direct labor cost of a casting.

A significant increase in the degree of control that can be exercised results from the use of work measurement standards, since the estimates accuracy degree is greatly increased. Since, however, direct labor is still paid on an hourly basis, there is no incentive for labor to reach and maintain a particular production. Direct labor cost per unit will then fluctuate with changes in production from day to day.

Wage Incentive System

The final and most effective direct labor control is provided by a wage incentive system based upon direct labor time standards established through work measurement. The plan of incentive payment which is receiving the most widespread acceptance today from both management and labor is the standard hour plan. It compensates labor for production over standard on a one-for-one basis. Under this incentive plan, if a worker produces 10 per cent more than the standard for the job, he receives incentive pay equal to 10 per cent of his negotiated hourly rate.

Here is the ideal situation for direct labor cost control, as long as the worker at least reaches standard on the job. Above standard, the direct labor cost per unit is constant. Most labor contracts covering incentive plans today permit management to remove a man from a job, if he is unable to meet an accepted standard, within a relatively short period of time. The use of incentives then relieves the supervisor of much of the burden of obtaining adequate rates of production, leaving him more time for other extemely important jobs such as control of departmental expenses.

The exercise of control over direct labor cost is essential if manufacturing cost is to be controlled, and the profit objective realized. There are many methods of controlling direct labor, but the best one to use depends primarily upon the foundry's size. The important thing is for top management to decide to take action and set the stage for an effective program of direct labor cost control.

Direct Material

By direct material it is meant all material which may be practicably charged to an individual pattern number in the foundry, where direct material is made up primarily of cold metal cost. This, of course, includes pig, scrap and alloys.

Typically, there is nothing much a company can do to control the prices that it pays for its cold metals. However, there is something effective most foundries can do to control the cost of their cold metal consumption.

Customers' metal specifications are normally expressed in terms of the chemical analysis of the metal and its physical properties. This leaves the foundryman free to brew his own mixture so long as the end result satisfactorily meets the specification. Often several different mixtures can be used to provide the same specification.

The prices paid for scrap vary in relation to pig, and between the various kinds of scrap. In 1954, for example, steel scrap was selling at only ⅔ the price of cast scrap, whereas in less than two years' time it was commanding a premium over cast scrap.

Where practicable, two or more different techni-

cally satisfactory mixture sheets should be drawn up for each different type of metal required. At least once each month these mixture sheets should be extended into a cost per ton, using the current purchase price of all metals included in the charge. The lower cost mixture should then be selected for use in the melting operation. The quantities of the various metals and alloys to be purchased should then be re-established according to the planned consumption.

The melting and purchasing supervisors must keep in close touch with one another in a rapidly changing market, in order that the company might produce the lowest cost mixture that will meet the specifications.

Overhead

The remainder of the cost, making up total manufacturing cost after direct labor and direct material, is referred to by several different names. Some of these are overhead, indirect manufacturing expense, burden and on-cost.

In the typical ferrous foundry overhead comprises from ½ to ⅔ of the total manufacturing cost. In non-ferrous foundries, the proportion is considerably lower due to the relatively high metal cost of the various alloys produced. However, if we look at the overhead as a percentage of controllable cost, which is the basis for competition between foundries, then overhead becomes about 55 to 80 per cent of total foundry cost of producing all types of metals.

The specific percentage depends primarily upon the degree of mechanization of the foundry. This high proportion of total cost makes the control of overhead of vital importance to the company's success.

Overhead cost, more than any other, is a reflection of top management policies and decisions. The size and type of staff, the amount and type of equipment, the kinds of services supplied to direct labor—and other factors making up a sizeable portion of the overhead cost are determined by management decisions. Some of these policies and decisions concern the type of casting a foundry is to produce, the market to which it plans to sell, the services which it wishes to provide to its customers and the rate at which the company plans to grow.

Once a control program for direct labor has been established, front line supervisors can generally be counted upon to hold relatively tight rein over their cost. During the conduct of their direct supervisory duties, it will become apparent to them when there is insufficient work to be performed and they will make the necessary lay-offs. With the use of the predetermined times, they have means of controlling daily direct labor productivity and become aware on a continuing basis of the responsibilities in this area. The same is not true generally of overhead cost.

The front line supervisor must also be the key man in expense or overhead control. All too often he, along with many members of management, consider overhead to be essentially a fixed noncontrollable cost. This is not true in the foundry.

Only about 10 per cent of total overhead cost is typically made up of such truly fixed items as depreciation, light, heat, taxes and insurance. Even these are only fixed in the sense that they cannot be controlled from period to period. They can be altered on a longer term basis as the result of management decision and action. All of the remainder of overhead cost is variable to some significant degree. Some of the most controllable of these costs are 1) departmental indirect labor; 2) production supplies (indirect materials); 3) equipment maintenance and repairs; 4) pattern and flask expense, and 5) general plant labor.

The most effective way to control departmental labor is through the use of daily, or at least weekly, reports showing the amount of indirect labor in relation to direct labor.

Monthly Cost Statements

This report should be submitted to management as well as to supervision. It is the exceptional supervisor who does not need periodic prodding by management to keep his indirect labor in line with direct labor. To be sure, the ratio of indirect labor is bound to increase somewhat as volume decreases, but by careful planning the supervisor, in the re-allocation of workers' duties and a tightening up of supervision, can do much to keep it in line.

The remainder of overhead costs can be most effectively controlled by management through the analysis of monthly overhead cost statements, which must also be distributed to supervisors for their individual departments. If these monthly overhead reports are to be effective they must be based upon an adequate chart of cost accounts. There must be a sufficient number of accounts with their content clearly defined so that a particular figure on the cost statement may be quickly related to some physical aspect of operation.

Suggested charts of accounts, complete with the description of the items of cost to be charged to each, are readily available from trade associations. In particular, the Gray Iron Founders' Society, the Malleable Founders' Society and the Non-Ferrous Founders' Society have prepared excellent cost manuals available at nominal cost.

The simplest type of cost report lists, for each department and each cost account, the amount of money spent during the period. Unless a budget has been prepared in advance, the one set of figures by themselves are not of too much value. It should be compared with figures for fairly recent previous months. The differences in volume from month to month in the jobbing shop in particular make it difficult to compare absolute dollar amounts between two or more sets of figures. This can be remedied to a significant degree by expressing each one of these items of cost in cents per pound or dollars per ton of good product produced.

This greatly reduces the most serious distortions due to changes in volume, and enables the spotting of other variances for study to determine the reasons for the increase. An effective technique is to develop a target overhead cost statement by recording the

best verified cents per good pound figure for each cost item, and using it as a standard of comparison each month. Each time a new low for an item is achieved, it should be substituted for the previous low on the target statement.

An effective method of cost control for the larger foundry is the preparation and use of an indirect manufacturing expense or overhead budget. The first step in the preparation of this overhead budget is to make a sales budget. Then, by an analysis of current costs and plans for cost reduction in the near future, a manufacturing plan can be made. This plan, expressed in dollars and cents, for each cost account and each department, becomes the manufacturing cost/budget.

Great value is obtained from the preparation of this budget, since it forces all levels of management to plan ahead for at least the period covered by the budget in order to arrive at the budgeted cost figures. The usual practice is to budget on a monthly basis for one year in advance.

Budget Disadvantage

One disadvantage of this type of budget is that the absolute cost figures budgeted for each month are dependent upon the amount and type of work produced. This disadvantage can be minimized by budgeting the amount of direct labor for the particular volume forecast, and then by expressing each item of overhead as a percentage of direct labor. If effective control over overhead is being exercised, these percentages should tend to remain constant as volume decreases.

This obviously does not apply to such fixed costs as depreciation and insurance, but these percentages can be left off the report or ignored, since it is fully recognized that they are not controllable by this method.

Often this type of budget is a forerunner, in a larger company, to the preparation of variable budgets. This type of budget eliminates, or greatly reduces, most of the objections to the fixed budget. It is prepared by analyzing every expense account to determine what cost items are essentially fixed and which are variable. For each variable item a decision is made as to with which readily measurable characteristic of operation it varies most closely. Typical examples are direct labor, tonnage and time or working days per month.

With this system of budgeting cost control, the accounting department calculates how much should have been spent in total dollars for each account on the control statement, under the actual conditions of volume and so on, encountered during the particular month. This has tremendous appeal in dealing with production supervisors who are so well aware of the effect of volume on costs that it tends to cloud their appreciation of significant cost information provided by the fixed budget and its percentage figures to direct labor.

Regardless of which of the above general techniques is used to point out the areas of cost which are out of control, the most effective approach to bringing these costs back into line is the same. Meetings should be held every month between the department supervisors, the cost department and management. Prior to these meetings, all supervisors should have received the cost statements for their own department and should have made some study on their own, and with the cost department, as to the reasons for their out-of-line costs.

At the monthly cost control meetings the supervisors should be called upon to explain as much as possible the reason for their out-of-line costs, what steps they have already taken to remedy the situation, what steps they plan to take and to ask advice or assistance in reducing costs in any area which is out of control. Make sure at these meetings that the supervisors know where they are going, and how they are doing. Do not pass up the opportunity to comment on these items of cost that have been brought back into line by the supervisors, or on items in which a department has shown marked improvement.

CONCLUSIONS

Do not try to analyze and control too much every month, otherwise nothing receives sufficient time and attention to achieve effective results. The setup, or layout of general cost control statements to be submitted each month, should remain the same over a long period of time unless there is an important reason to change. This is necessary to provide an effective measure of progress being made. The number of these reports, however, should be at an absolute practical minimum.

When an individual area of cost, represented by one figure on the basic cost control statement, is out of line, and the supervisor does not know the reason, or feels he has insufficient information to enable him to bring it under control, more detailed special reports should be planned. The layout and type of these reports should be determined by the supervisor requesting them, not by the cost department, although the ideas of the cost department should be solicited. If the supervisor has an opportunity to say what it is he wants reported to him, and in what way, he will make far more effective use of the information when he receives it.

This type of reporting should be flexible, so that concentration can be brought to bear on the troublesome areas. It is important that these special reports be discontinued as soon as the troublesome area has been brought under control, otherwise the cost department gets bogged down with such a heavy load that it has no time left for analyzing cost accounts or working with the supervisors on cost reduction.

When more items of cost are out of line than it is practicable to concentrate on at one time, the order selected for tackling these jobs should be dictated by the absolute dollar magnitude involved. For example, it will be potentially much more profitable to attack a $20,000 item of cost that is 5 per cent out of line, or $1,000, than a $500 item that is 25 per cent out of line for only $100.

DESIGN AND WELDING OF ALLOY CAST STEEL

steam turbine applications

By L. W. Songer

ABSTRACT

The service requirements of modern steam turbine-generator equipment necessitate that castings and cast weldments be of the highest quality and have maximum reliability. The requirements for proof of quality, and control of all phases of manufacture, are far more exacting than the requirements for structural castings most foundries are accustomed to making.

The design, welding and quality control aspects of high quality castings are discussed relative to greater participation by foundries in these important phases of manufacture. Ways of protecting the present market, and regaining lost business through a better understanding of the customers' needs, are pointed out.

INTRODUCTION

The design of modern steam turbine-generator equipment depends to a great degree on castings. The present-day high pressure and high temperature operating conditions require that castings of the highest quality be designed and produced to meet both the ever increasing demands of service and economic manufacture.

Many castings are produced only a few times, therefore, there is little opportunity to gain experience by making and evaluating several castings. Close cooperation is required between the foundries and design engineers since the first casting generally must be used.

Starting in 1905, with temperatures of 500 F, the steam turbine industry today has reached operating temperature levels of 1150 F (Fig. 1). It is interesting to note that this has resulted in an average increase over the years of 12 F per year.

The development of alloy materials and the improved designs of turbines and boilers has permitted a continual increase in the initial pressures for steam turbines from the 500 psig to the 4500/5000 psig of today's highest pressure turbines (Fig. 2). This increase in temperature and pressure, along with many design improvements over the years, has improved the overall efficiency of steam turbines, as shown in the station coal rate (Fig. 3). The improvement in the coal rate has been reflected in the lower cost of electricity.

Recent surveys have shown that the nation's electric power generation is increasing more than twice as rapidly as the rest of the economy. The use of electric power is expected to continue at a high rate of in-

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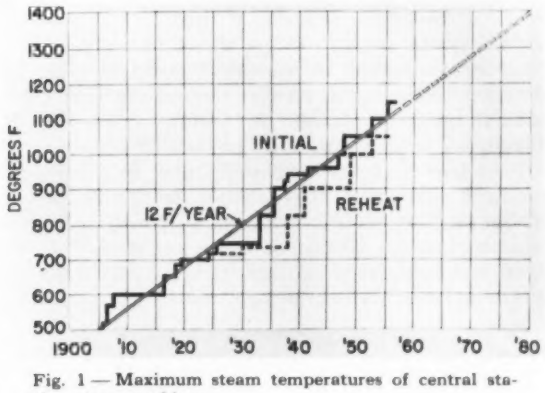


Fig. 1 — Maximum steam temperatures of central station steam turbines.

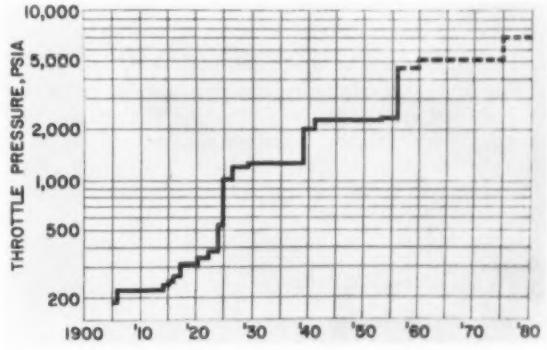


Fig. 2 — Maximum pressure of central station steam turbines.

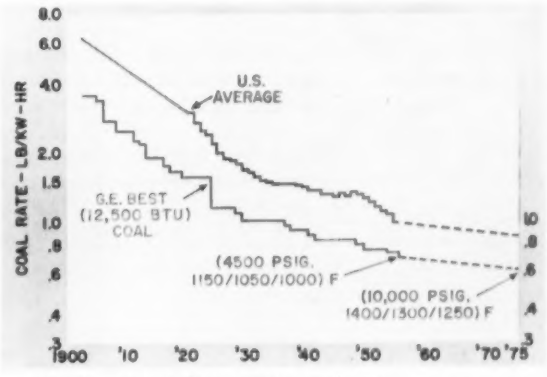


Fig. 3 — United States station coal rate.

crease for the next 20 years, and with this will come further advances in pressures and temperatures. Steel foundries can share in a greater portion of this potential business, and thereby better contribute to our way of life.

Design and welding aspects of large alloy-steel castings for use in steam turbines operating at temperatures up to 1050 F and at pressures up to 3500 psi are discussed. The castings may vary in weight from 1,000 to 85,000 lb. Comments will be given regarding the use of forged and fabricated parts to replace castings, and how business lost to such vendors might be regained through more direct consideration of the customers' needs.

CASTING DESIGN

The design requirements of castings for the power generation industry today are, 1) reliability, and 2) designs which can be produced at reasonable costs. Good designs do not happen by chance. They are the result of a carefully thought out and calculated engineering approach to produce a component which will satisfy a given set of conditions.

The designer must have a thorough knowledge of cast and wrought materials, and must be willing to use these materials either singly or in combination if quality components are to be produced. In addition, he must consider other important design criteria such as structural strength, heat flow and distribution in the component during service, method of casting, welding, machining and nondestructive inspection. He is only one of a group of engineers who must contribute to the production of quality castings. The materials engineers, the metallurgists, the welding engineers and foundry design engineers all have important contributions to make in their respective fields.

The foundry design engineer can be most helpful if he is called in at the layout stage, so that the best foundry practices and principles can be considered along with service requirements and optimum costs. This practice is now being successfully used by progressive manufacturers.

Large castings are inclined to be overdesigned because of the necessity of tapering walls for considerable lengths. This excess weight not only makes the casting more costly but also increases the costs of other components, particularly the supporting structures. Since stress considerations are of the utmost importance, it is necessary to strike an optimum balance between design and casting requirements. When recommending the addition of taper to existing walls of troublesome castings, the entire stress distribution must be reviewed if weights are to be lowered.

The developments in the welding industry have benefited both the fabricators and the steel foundries to a great degree. Since welding with its required nondestructive inspection is a costly operation, no component should be cast in more than one piece to be welded together if it is possible to cast a single part of the required quality.

CASTING DESIGN REVIEWS

The following aspects should be considered when reviewing casting designs:

1) Function of the component and critical areas.
2) Service record of similar castings.
3) Operating temperature and pressure.
4) Material specification and test requirements.
5) Heat treatment.
6) Weldability of material.
7) Welding specification – including code requirements and extent of repair welding permissible.
8) Post-weld heat treatment.
9) Number of castings to be ordered.
10) Type of pattern, core boxes, new or made from an existing pattern.
11) Position in mold for casting.
12) Projections which could possibly cause casting difficulties. Should they be removed, cast separately and welded or bolted on?
13) Should the main casting be made in more than one piece? If so, can an adequate weld preparation be made which is accessible for nondestructive inspection?
14) Junctions of unequal walls, flanges, pipes, etc.
15) What directional feeding is provided by actual drawing dimensions, internal and external padding? Will the padding be removed and how?
16) Internal and external chills (Internal chills used only with purchasers' permission).
17) Tolerances on wall thickness and as-cast surfaces.
18) Stock allowable on finished surfaces.
19) As-cast surface finish requirements.
20) Nondestructive inspection requirements.
21) Tie bars for maintaining dimensions during casting and/or heat treatment.
22) Location of risers, favor placing them on machined surfaces.
23) Should a scale model be made?
24) Sample castings for smaller parts.
25) What new foundry procedures might be used to improve quality or make casting of unusual contours possible, such as the use of exothermic materials in certain areas?
26) The final consideration is a recheck to see if the overall weight can be reduced without jeopardizing the casting.

Foundry Functions

Foundries should have complete control over the design and planning of patterns. Designs and patterns should be developed to suit a particular foundry's facilities. One way to initiate control is to educate the customers' product designers to show wall tapers, feeder pads and other requirements, which will remain on the delivered casting directly on pattern drawings, and to dimension them. Present-day casting problems cannot be left to the skill of the patternmaker and molder alone.

In general, foundries are reluctant to ask for design changes on castings used by the manufacturers of large equipment for fear that some may think they are incompetent to judge. This belief is wrong. Competent product design engineers respect foundry engineering advice, and are willing to discuss any phase of casting improvement. The representatives sent out for these discussions should have a complete knowledge of casting design and foundry practices.

In a period when the technical aspect of every industry is increasing at an ever-accelerating rate, there is some question whether the foundry is keeping up a comparable pace with respect to casting design.

Foundries many times develop new and ingenious methods of which they should be justly proud. These methods should receive more publicity for the benefit of casting product designers and users.

In making quality castings, calculated risks of the following type should be held to the absolute minimum:

1) The heat that is thought adequate.
2) The core that is baked too hard, or burned.
3) The risers that are too small, or not completely filled.

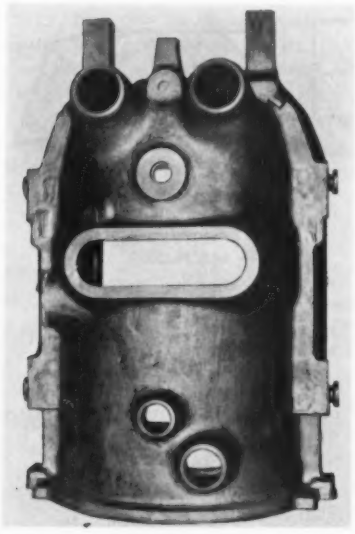
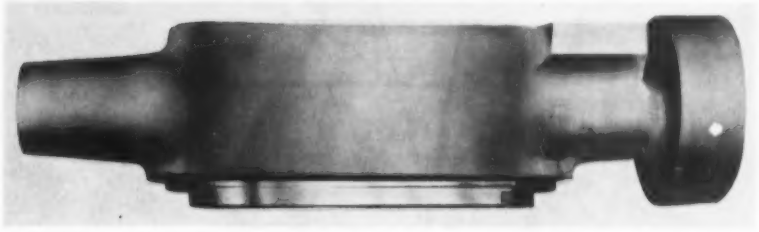


Fig. 4 — (Left) Turbine shell casting designed for separate welding on steam chest.

Fig. 5 — (Below) Steam chest with an integral inlet flange, weld preparations partially machined.



4) The riser that is not properly attached.
5) The flask that is too small.
6) The worn-out and distorted pattern.
7) The broken core that should have been scrapped.
8) The mold that is shaken out too soon.
9) The gating which never worked in the past.
10) The dirty mold.
11) The extra chills that no one will ever find.
12) The casting that is cast in the wrong position just to suit existing flasks.
13) The molding practices which are left entirely to the molder.
14) The metal that is poured too cold.
15) The riser that is burned off without proper preheat.
16) The inadequate heat treatment.

These items can and must be controlled for high-temperature, quality castings. Casting defects are seldom an accident.

Present-Day Designs

High-quality complex castings are produced today by making the casting in more than one piece for subsequent welding. Figure 4 shows a turbine shell designed for use with a separately cast and welded-on steam chest. Figure 5 shows the separately cast steam chest. Figure 6 shows a valve casing with a separately cast flanged elbow, assembly welded. Figure 7 shows a weldment for a steam inlet connection. Three castings and two pipes were welded at the locations shown. The angle inlet tee was designed to save space and eliminate one weld.

Centerline shrink in the walls, and shrinkage at the seat fit, have caused considerable difficulty in many large valve casings. One method of casting which has entirely eliminated the shrinkage problem is shown in Figs. 8 and 9. These casings are cast in the vertical position with the walls tapered and the excess metal is machined out. While this may seem like casting ingots, the overall quality is so good that this method of casting and machining is less costly than making castings in the conventional way and then repair welding.

This example points out the need for a complete understanding of all manufacturing processes. Many times it is more economical to purchase one higher-priced and higher-quality component if the remaining processes can be completed with less work, and the final cost will be actually lower.

Figure 10 shows how a hot spot and the attendant shrink are avoided by making the stock for finish parallel to the finished surfaces on stub pipe and weld preparations.

WELDING

The composition of the alloy steels, the weld deposit and the heat treatment of these materials used for castings and welding at the writer's plant, are shown in Table 1.

Weld Preparations

The guiding thought in the design of all types of weld preparations is to obtain fusion throughout the entire wall thickness, while at the same time keep-

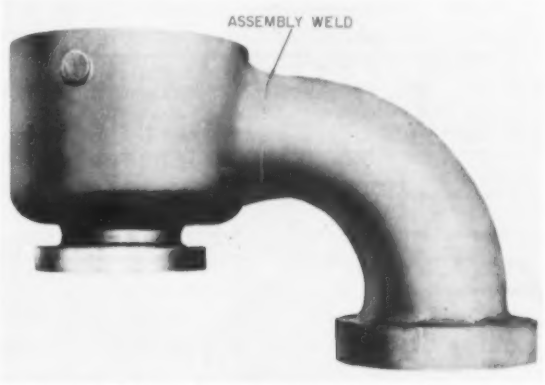


Fig. 6 — Valve casing with separately cast flanged elbow, assembly welded.

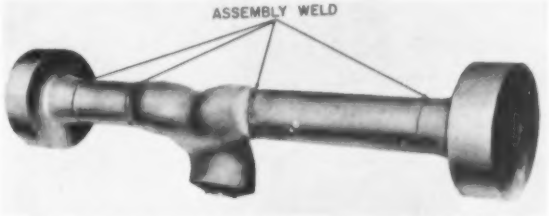


Fig. 7 — Weldment, consisting of cast flanges, inlet tee and two pieces of wrought pipe.

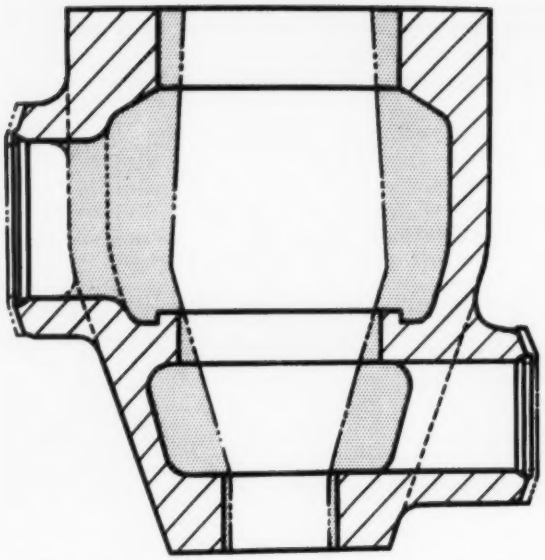


Fig. 8 — Stop valve casing cast with tapered walls which are machined to contour.

ing weld shrinkage and the attendant locked-up stresses and distortion to a minimum. To secure full penetration on a consistent basis, proper access to the root is a prime requisite, which allows the welder to follow the welding progress and to maintain control of the arc. This control is particularly significant where lack of penetration or excessive penetration causes defects on the inside of the joint, which cannot be corrected by removal and rewelding from the inside.

TABLE 1 — COMPOSITION AND HEAT TREATMENT OF MATERIALS

Material	Composition, % Cr	Mo	Mn	C	V	Heat Treatments
Cr Mo	1.25	1	0.70	0.20		Normalized 1920 F min.
Cr Mo V	1.25	1	0.70	0.18	0.20	Tempered 1250 F min.
Cr Mo Weld Metal	0.50	1	0.90	0.12		

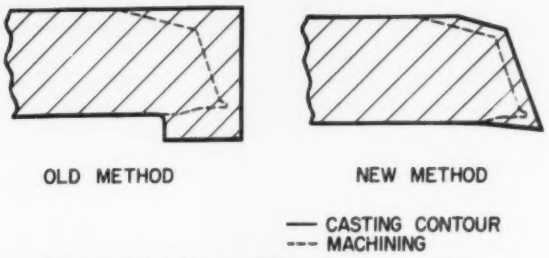


Fig. 10 — Method for adding stock on machine finished weld preparations.

To minimize shrinkage, distortion and fabrication costs, it is desirable to keep the amount of deposited weld metal to a minimum. These requirements, together with the welding process to be employed and any special conditions imposed by specific application, must receive careful consideration.

Figure 11 shows typical weld preparations for joining heavy-walled sections. Figures 11a, 11b, and 11c show weld preparations used for manual metal-arc welding and for manual or mechanized submerged-arc welding. Figure 11d shows the preparation for inert-gas metal-arc welding of the root pass. This preparation can be used either with or without a consumable backing ring. Backing rings of either the integral or separate type are machined out where possible (Fig. 11a). It is also advantageous to machine a secondary angle on the outside diameter of casting (Fig. 11a), to insure uniform weld thickness by having a uniform outside diameter.

WELDING METALLURGICAL ASPECTS

Preheat

Welds which have a high degree of restraint and high residual stresses are encountered during fabrication and repair welding. The size of the planned welds ranges from 1 to 6 in. in wall thickness, many being in the 3 to 6-in. range. Also, the usual contour of casting defect repair welds is of an elliptical cup

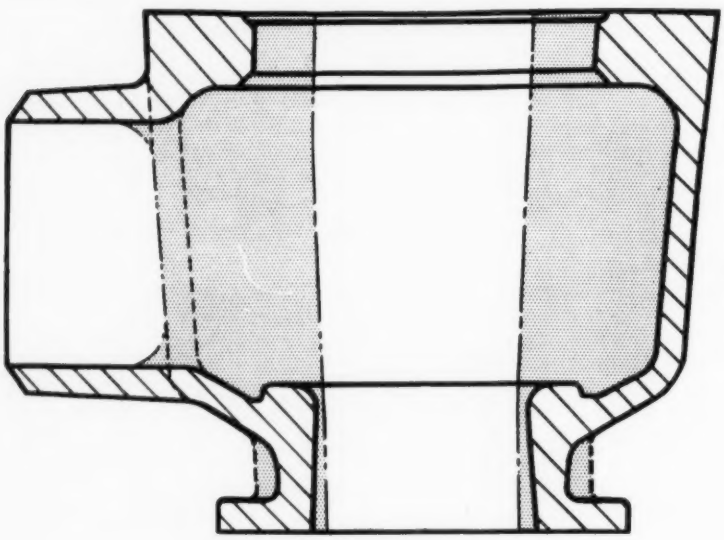


Fig. 9 — Intercept valve casing cast with tapered walls which are machined to contour.

shape, and can be in heavy overall sections such as a flange which might be 24 in. thick. In large section sizes, high multiaxial residual welding stresses can cause material failure with little deformation.

For planned and repair welding, the components are preheated to 450 F minimum. This temperature is above the impact transition temperature of the base materials (Fig. 12).

The impact test is an indication of the resistance of the material to triaxial stresses under a notch. As mentioned previously, repair welds in large sections can have high triaxial residual stresses. The use of preheat above the impact transition temperature holds the material in a temperature range in which its resistance to failure under triaxial stresses is increased.

Experience indicates that the maintenance of the preheat during welding is imperative to the successful processing of these highly restrained welds. Furthermore, it is advantageous to continue the preheat temperature until postweld heat treatment can be effected. This eliminates the possibility of having welds with high residual stress subjected to temperature ranges where their resistance to crack propagation is decreased.

Heat Treatments

The main objectives of subcritical postweld heat treatments are to relieve residual welding stresses and temper hard heat-affected zones. By raising the weld to a high temperature, the yield strength of the material is lowered and a relaxation of the residual stresses is accomplished. The temperature and the time at the temperature are the main variables of a stress-relief cycle. The temperature is more important variable here than the time at temperature.

The Cr-Mo and Cr-Mo-V steels considered herein are given a subcritical stress-relief cycle at 1275 F.

In base materials whose heat-affected zones are subject to secondary hardening, the time at temperature is also an important variable. This time must be long enough to temper the heat-affected zone through its secondary hardening peak to a lower hardness approaching that of the base metal. The Cr-Mo-V steels considered herein are subject to this type of hardening, and are tempered satisfactorily by 8 hr at 1275 F.

The components under consideration have great variation in section sizes. This necessitates carefully planned furnace loading and thermocoupling to assure that all sections receive the proper time-temperature cycle.

Some large turbine castings are processed in the fully annealed condition during repair and planned welding. The advantages of processing castings in this condition are lower as-welded residual stresses, greater crack-propagation resistance and a more complete relief of residual welding stresses by a final above-critical heat treatment.

The annealed chromium-molybdenum castings have an average room temperature yield strength in the range of 45,000 psi, while the normalized and tempered chromium-molybdenum castings have a room temperature yield strength in the range of 70,000 psi. This favors lower as-welded residual stresses for welds made in annealed base metal.

Figure 12 shows typical impact transition curves

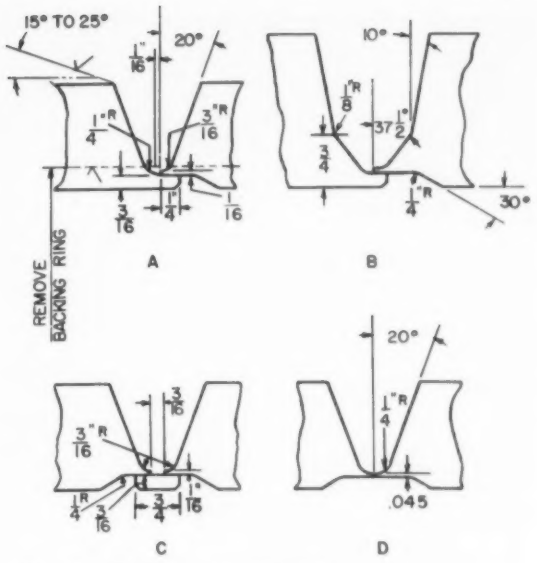


Fig. 11 — Typical weld preparations.

for the same analysis of annealed and fully heat-treated (normalized and tempered) chromium-molybdenum-vanadium material. The transition temperature is lower for the annealed condition. However, the main difference to be cited is the greater energy-absorption capacity of the annealed material. At 200 F, the normalized and tempered material has a value of 45 ft-lb vs. 74 ft-lb for the annealed material (Note points *A* and *B* in Fig. 12).

This indicates a greater crack-propagation resistance for the annealed condition in this temperature range. It is difficulty to maintain full preheat on some of the large castings (e.g., 80,000-lb large turbine shells), which require considerable handling time to reposition for further welding. Therefore, the annealed material will be less subject to repair weld cracking when it is not possible to maintain a full preheat temperature until a postweld heat-treatment is performed. Experience in the author's plant has generally verified this.

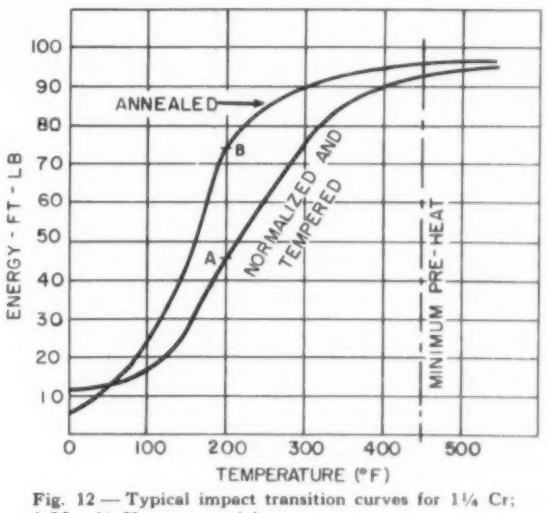


Fig. 12 — Typical impact transition curves for 1¼ Cr; 1 Mo; ¼ V cast material.

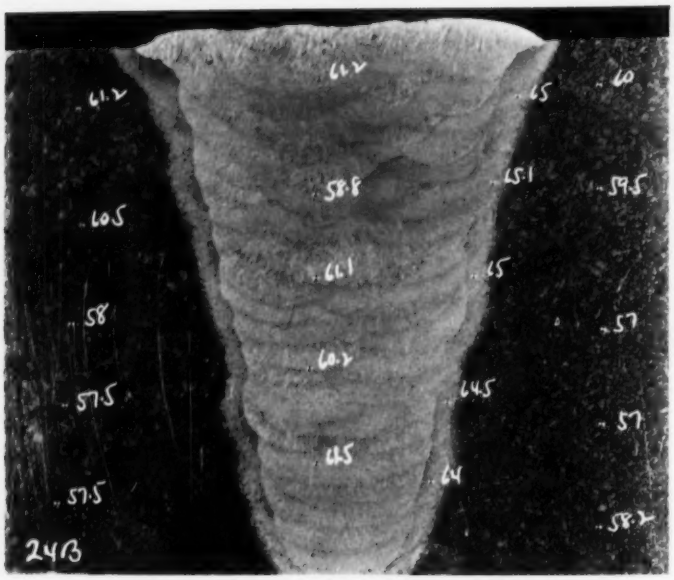


Fig. 13 — Photomicrograph of ½ Cr — 1 Mo Weld in 1¼ Cr — 1 Mo — ¼ V base metal prior normalize and temper heat treatment. Rockwell A hardness survey. 1¼ ×.

The normalize and temper heat treatment, after all planned and repair welding, assures complete relief of residual welding stresses. After a stress-relief cycle, which is a subcritical anneal, the level of remaining stresses approaches the yield strength of the materials at the stress-relieving temperatures. In many cases, these stresses can be as high as the high temperature working stresses. Service experience has indicated sound weld deposits with high-temperature, stress-rupture failures. It is believed that residual welding stresses contributed to these difficulties.

The assurance of complete stress relief by the post-weld normalize and temper heat treatment minimizes cracking. This is of particular importance where heavy section sizes are subjected to high thermal stresses in service. The normalize and temper heat treatment also completely eliminates the heat-affected zone and any "metallurgical notches" associated with it (Figs. 13 and 14).

Distortion and scaling are experienced during the normalize and temper heat treatment. These effects are overcome by the use of tie bars, planned furnace loading and the allowance of extra stock for finish machining.

Intermediate Stress Relief

The removal of casting defects by flame gouging can build up high residual stresses and hard heat-affected zones in one area. By using an intermediate subcritical stress relief, it is possible to minimize these so that subsequent defect removal or repair welding can be done without cracking difficulties.

Also, it has been found beneficial to use an intermediate subcritical stress relief during the repair

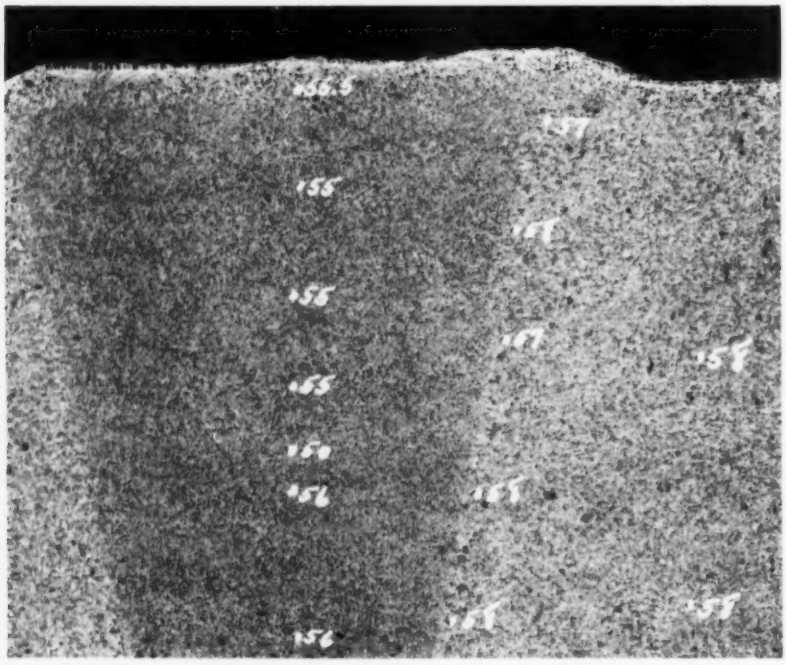


Fig. 14 — Photomicrograph of ½ Cr — 1 Mo weld in 1¼ Cr — 1 Mo — ¼ V base metal after normalize and temper heat treatment. Rockwell A hardness survey. 2 ×.

welding of large areas, in locations where high restraint is encountered.

Electrode Composition

The deposited chemical analysis of the weld metal used for the foregoing casting compositions is shown in Table 1. Only low-hydrogen-type coated electrodes are used for metal-arc welding. However, the majority of the welding is done by the submerged-arc process. At present, work is being completed on the development of chromium-molybdenum-vanadium weld deposits for submerged-arc welding.

WELDING PROCESS TECHNIQUES

The fabrication and repair of large castings are accomplished through the use of the following processes: Manual-arc; manual inert gas metal-arc; mechanized submerged-arc, and manual submerged-arc. These processes are employed so that they complement each other. All submerged-arc welding is done using $\frac{5}{64}$-in. diameter electrode, with currents in the range 300-550 amp and 30-55 arc volts.

It is important to note that a written procedure is prepared for each specific application. Test joints are welded using these procedures, and are evaluated prior to release of the procedure for production use.

All welders are qualified in the processes and procedures which they will use in production. A large portion of planned and repair welding is accomplished using manual submerged-arc welding. For this work, welders have been trained and qualified in both manual metal-arc and manual submerged-arc welding. Qualification procedures are used for manual submerged-arc welding, which includes radiographic evaluation. Assignment of these welders is controlled so that only one welder works on any weld from its beginning to its completion. This method makes one man responsible for the quality of the entire weld.

QUALITY CONTROL

Castings, weldments or forgings used for high pressure, high temperature power generation equipment must be of the highest quality, and the quality must be proved according to written procedures. A difficulty which causes an unplanned outage of a large steam turbine may cost the power producer many thousands of dollars in lost revenue, depending on the size of the unit.

Quality control in the foundry for casting and welding is an effective system for insuring that procedures are established and followed, and a means provided for measuring the result. It gives an up-to-date record of performance and conditions so that quality standards can be maintained continuously. Castings with walls up to 6-in. thick require a greater degree of precaution and closely controlled practices in all phases of manufacture. Therefore, a definite quality control program is imperative. Casting repair welding is a normal, accepted part of the manufacture of high quality pressure-containing castings, and is generally necessary in order to maintain required standards.

Quality control might well be the means of providing information and control, which will aid the most in changing the production of castings from an art to a science.

NONDESTRUCTIVE INSPECTION

No attempt will be made to discuss the various methods of nondestructive inspection. However, all pressure-containing castings used in the manufacture of large steam turbines are inspected thoroughly by more than one method after cleaning, rough machining, planned and repair welding. Certain manufacturer's requirements are more rigid than the normally known codes. Foundries producing these castings must have an intimate knowledge of radiography, magnetic particle inspection, liquid penetrant inspection and ultrasonic inspection. The limits of each method must be thoroughly understood. It is not wise to use one method to the exclusion of all others. It is most satisfactory for foundries to have their own nondestructive inspection facilities.

Specifically, after manufacturing operations noted above are performed, pressure-containing castings are inspected as follows:

1) Visual.
2) 100 per cent magnetic inspection (ferritic materials).
3) 100 per cent liquid penetrant (nonmagnetic materials).
4) Radiographic.
5) Hydrostatic test of pressure components.

Radiographic equipment used by the author's company includes 20 mev betatron, 1,000,000-volt x-ray and 250,000 volt x-ray. Stereoscopic radiographs are used to a considerable extent in determining the exact location of defects with respect to wall surface.

Disposition of Defects

The following evaluations are considered in determining the final disposition to repair or condemn each component:

1) Location and size of defect.
2) Orientation with respect to other defects.
3) Proof that the defect has been completely removed.
4) Service experience.
5) Stress consideration (static and thermal).
6) Limitation of inspection methods.
7) Accessibility for welding.
8) Machining and heat treatment status.
9) Strength of repair weld.
10) Economics.

Shallow surface defects may be faded out and blended into the surrounding surface where location and stress levels permit and where satisfactory appearance can be maintained.

MARKET DEVELOPMENT

The technical growth of foundries in the past ten years has been considerable. Many new processes have been developed, mechanical properties have been upgraded on existing materials and, in general, the quality of castings has improved. In spite of these gains, the total volume of casting business has been dropping for the past seven years. A better under-

standing of the customers' needs, and a closer look at the reason for orders lost to competitors in other fields, may well give the answer.

The steel foundries' main competition in the past has been the fabricators of welded products. Today, forging producers are serious competitors on items up to approximately 5000 lb. Ductile iron also is replacing some carbon steel castings.

Many purchasers are interested in procuring castings which have been completely nondestructive inspected and repair welded to written procedures. Some foundries do repair welding today, but not many are equipped to do machining. The most advantageous time to nondestructive inspect castings is after rough machining. In this state many surface defects have been entirely removed, and excessive repair welding is avoided.

Practically all fabricators and producers of wrought materials have at least rough machining facilities.

Is it not logical that foundries should be deeply interested in the rough machining, nondestructive inspection and repair welding of their own castings in order to deliver the highest quality product to quality-minded customers?

Some castings have been changed to forgings because of poor quality. The fabrications or forging may cost more than the original poor-quality castings, but they are still less costly than the repair-welded and reheat-treated castings. Total casting cost may be doubled because of repair welding. Quality castings can regain lost business.

The producers of fabrications have gone to the manufacturers and looked over castings to see where they could produce a comparable part with improved

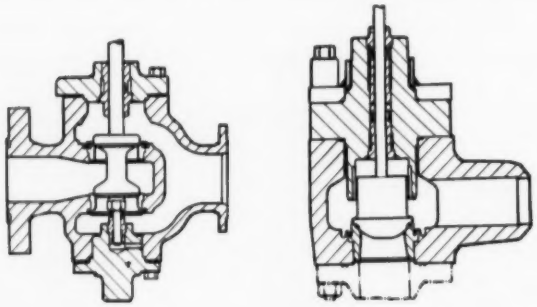


Fig. 15 — Balanced valve design to simplify casting.

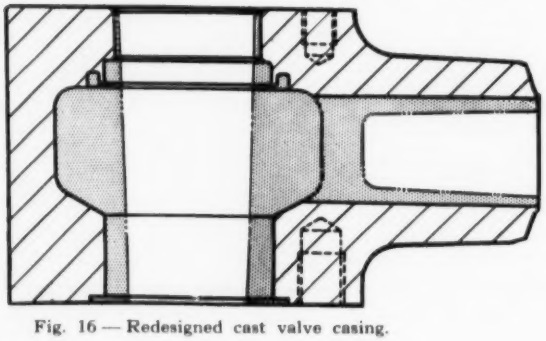


Fig. 16 — Redesigned cast valve casing.

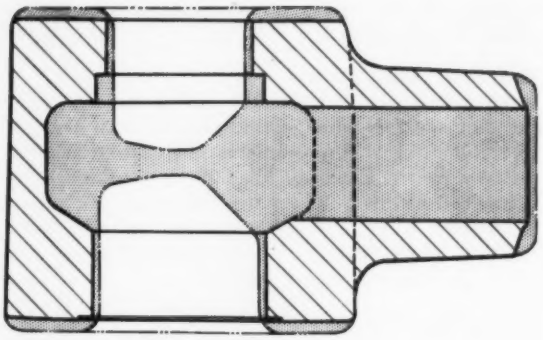


Fig. 17 — Forged valve casing.

quality and lower weight, and sell a satisfactory product at a lower price. Considerable engineering effort goes into each project, with particular attention and study given to all phases of manufacture, including welding, heat treating and nondestructive inspection. Whenever a part becomes difficult or impossible to make with existing equipment, a casting, and generally a complex one, is put in the weldment.

One can only admire any group which is vigorous and far-sighted enough to take advantage of all present-day engineering and manufacturing know-how, and produce acceptable quality products at lower costs. Careful selection of products and intensive engineering effort can produce astounding cost improvements.

New Business Possibilities

Engineering-wise foundries have the same opportunities as the fabricators of welded products, and the producers of wrought materials, to secure new business. They should recommend changes and develop designs to favor the proper use of castings made in the most favorable way. There is nothing wrong with using wrought parts in these predominant cast weldments when the design is improved. Castings made to the generally simple shapes of forgings offer few foundry problems. Concessions are made many times in fabrication designs. These same concessions may be given foundries for casting redesigns if they are requested.

Foundries are losing a lot of their potential business if they produce only the large or complex castings for components which cannot be made by other methods. A good look at the foundry competitors' products will reveal many items which can be produced by casting at equal or better quality and lower costs. It will require some digging to find these items.

Figure 15 shows a balanced valve assembly which was redesigned for both improvement in operation and simplification of the body casting. The body was cast with excess stock on the inside in order to avoid centerline shrink, and directional solidification was provided for as shown in Fig. 16. The castings were sound and no repair welding was required. This rough casting weighed 250 lb.

The forging group was able to produce a forging, as shown in Fig. 17, rough machine it to within $\frac{1}{8}$-in. of finished dimensions, and sell it for less than the rough casting. The foundry should be able

to cast and rough machine this casting for at least the same price. If the foundry does not have machining facilities, why not make price concessions when it is definitely known the customer is machining away stock that was added to insure sound casting? The purchaser does not pay directly for the risers or pads burned off in the foundry.

Many dies for forgings are made from castings where the cavity is practically cast to size with a minimum of machine work necessary. The reduction in cost is considerable.

What has been done by foundries to reduce pattern costs for large castings in the past five years? While some foundries do not make patterns, their costs certainly add to the final cost of castings. Since many patterns for these large castings are used only a few times, what different construction could be used to produce less costly patterns?

Risers are burned off by hand in many foundries, leaving excess stock and/or undercutting. These two casting faults cost the customer a considerable amount of time and money. Machine guided burning torches should be more widely used, and other methods of riser removal, such as sawing, should be considered.

Important Considerations

Orders should be accepted in the casting range that can be made economically. It is important to understand completely the material specification and all test requirements. The intended use, special requirements or limitations must be thoroughly understood.

It is wrong to assume that good castings have been made from the pattern received. You may be given an order because some other foundry has been unable to produce the needed quality. The removal of all telltale evidence of how the casting was gated and risered when returning patterns is still practiced. Orders should be rejected unless you have the knowledge that a satisfactory casting or cast weldment can be made at a fair profit. The first casting of a given type should be evaluated before completing any order.

More scale models should be made and examined, in order to eliminate hot spots and aid in the planning of feeding and gating. Most drawings do not show junctions or section changes clearly. Sample castings cannot be made and sectioned to prove a design when you are producing castings up to 85,000 lb. However, plaster casts can be used effectively in checking many of the smaller parts.

When mistakes are made, do not attempt to repair them in your own manner. Instead, tell your customer. He may be able to save you a lot of work.

The recently established "Value Analysis" groups in many companies offer a new approach to customers. However, the value of discussing design problems with designers first hand is still of utmost importance.

Designers have access to considerably more information in the welding and fabrication fields than in the casting field. There is a general belief among many product designers that fabrications are always less costly because no pattern is involved. The number of parts to be produced often is forgotten. More information on castings should be available to designers.

A vigorous, large scale program is necessary to educate the present-day product designers and users of castings in the current foundry capabilities and the limitations of all foundry processes. The ability to prove the quality of castings by nondestructive inspection in the foundry should be provided and publicized to a greater degree.

CONCLUSIONS

Foundries can contribute much more to proper design of quality castings by a careful evaluation of the customers' needs and by the application of modern foundry engineering practices. Complex components of higher quality can be made by casting better quality individual parts which have been made in the best suited manner and assembly welded.

Sound welds can be made in heavy-walled, low alloy steel castings if closely controlled procedures are followed. Quality control and proof of quality is necessary to guarantee minimum service requirements.

There is a good potential market for high grade castings, but an educational program, to better inform designers and users of castings of the advances made in the casting industry and the present-day status, is needed to fully exploit this potential. In all events, aggressive efforts should be maintained to minimize the possibility of losing even more casting work. Foundries willing to devote engineering effort today to improve and understand the functions of their castings will be the leaders and profit makers of tomorrow.

ACKNOWLEDGMENTS

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NOTE: When this paper was written, the author included information and expressed opinions believed to be correct and reliable. Because of the constant advance of technical knowledge, the widely differing conditions of possible specific application and the possibility of misapplication, any application of the contents of this paper must be at the sole discretion and responsibility of the user.

ALUMINUM DIE CASTING METAL COST

its practical and analytical evaluation

By George H. Found and John Lapin

ABSTRACT

Fast developing technological improvements in die casting processes, the expansion of markets and competitive pressures have reduced unit cost greatly during the past five years. Resulting from this, the cost of metal has become a dominant factor in determining whether profits exist in normally resourceful die casting operations. Elementary analysis, supported by the experience of job shop operations, is used to demonstrate that exacting control of metal cost and metal handling are the most important factors in the success of a competitive, modern die casting operation where performance, quality, profit-making motives and competitive pressures must be met on an optimum basis.

A method of establishing the value of the separate factors contributing to the metal cost both in an overall operation and in an individual casting is discussed. A practical review is given of practices for minimizing metal costs in light of the foregoing.

INTRODUCTION

Literature gives extensive coverage of the various phases of die casting aluminum. Despite this, new developments both in the laboratories and on production floors are taking place in this expanding field more rapidly than the literature can cover. As a result, the literature does not emphasize sufficiently the relative effects of these developments on the various elements, particularly on the metal costs.

The scope of this paper is to consider briefly, from the standpoint of practical experience, the elements which appear to be of greatest day-to-day importance, their relative importance to each other and the way this relationship has varied during the evolution of recent years.

The most important cost item, not only from the magnitude standpoint but also from its dominating position in determining profit or loss position of the operation, has recently become the metal cost. The general improvement in speed of casting, the higher injection and locking pressures, improved die construction and changes in metal handling methods, have combined to cause this pronounced emphasis.

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One might easily forecast that metal cost is the big factor, but the degree to which this is so, especially in such a fast-changing industry, is deserving of constant review. The cost structure of castings in the die casting industry five years ago was sufficiently different to have caused direct labor and other elements to have shared the attention with metal costs. Advancement in techniques and requirements has since changed this relationship so that small increments in metal cost supersede all others in importance if it is assumed that foundry performance is at least average in other respects.

RESULTS OF EXPERIENCE

The specific factors accounting for the present emphasis are the increase in casting rates, the increase in casting and poured weights and the reduction in the other cost elements due to improvements in mechanization and handling.

It is not the object of this paper to supply compact answers to the metal cost problems. An analysis will be given which will be suggestive for appropriate treatment of the variables as they may apply to individual plants and operations.

In relatively complicated processes involving work being applied to a material flowing through a plant, the costs of the material initially are superseded by the attention given to improving the process, reducing labor costs, increasing the production rates and the quality and flexibility of the process. This has happened in the die casting industry. Despite this sequence, however, metal costs still have been a significant part of finished part cost.

With process improvements, and attendant improvement in cost, quality, production rates and breadth of market in the end product, the metal cost has evolved into the most important single cost factor. In many die casting operations, the metal cost has become so dominating that all other costs combined are relatively small when compared to the cost of metal.

The metal cost increases in imporance with respect to the total factory cost as production rates and individual casting weights increase. Thus, the current trend in the industry (higher rates and larger castings) has resulted in an increase in the ratio of metal

cost to the factory cost, and, consequently, in relation to the casting selling price.

Continually greater effort must be exerted, first in understanding the elements which contribute to the metal cost, and second, in the means used to control them.

DEVELOPING THE IMPORTANCE OF METAL COST GRAPHICALLY

It is interesting to note how the amount of metal handled per hour drastically increases with size and rate of production of castings in a normal die casting operation.

In Table 1 some typical die casting rates are shown for varying sizes of castings. These rates are compiled from actual operations familiar to the authors. Any die casting operation would show a similar relationship, with the hourly rates displaced upward or downward when plotted against the casting weight as the abscissa.

A general increase in casting rates, such as might result from automatic ladling or improved temperature control of the dies, will result in an upward displacement of the curve without substantially changing its slope.

Figure 1 graphically shows the relation between casting weight and production rate in pounds per hour.

The relative importance of metal cost to total cost can be visualized as pounds per hour increase due to either higher casting rates or larger casting size.

If the metal cost per casting is expressed as per cent of the total factory cost (disregarding at this point metal losses and using a uniform factory cost rate per machine hour), Fig. 2 shows the rise in metal cost with increasing production rates. Here the factory cost is the sum of the metal cost, direct labor and overhead. The ratio, metal cost: factory cost, may be considered to be approximately equal to the metal cost as per cent of selling price (for purposes of illustration, a uniform factory cost of $30.00/machine hr, and an ingot price of $0.25/lb were used). The values derived are shown in Table 2.

If the cost of the metal is deducted from the factory cost, and the resulting cost is termed manufacturing cost, then the ratio metal cost/manufacturing cost plotted against casting rates becomes a much steeper curve than that shown in Fig. 2. However, the curve is perhaps not truly reflective of the realistic relation that exists.

From the above considerations it becomes significant, in a quantitative way, that as the industry

TABLE 1 — TYPICAL CASTING RATES — ALUMINUM DIE CASTING

Casting weight, lb	No. of cavities	Shots/hr	Castings/hr	lb/hr
0.1	8	120	960	96
0.5	4	90	360	180
1.0	3	75	225	225
2.0	2	65	130	260
5.0	1	65	65	325
10.0	1	45	45	450
20.0	1	30	30	600
30.0	1	22	22	660

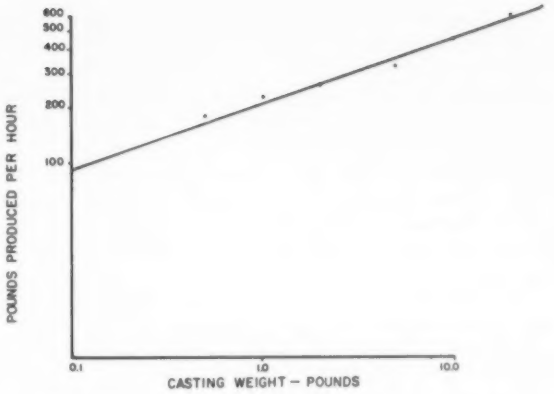

Fig. 1 — Relationship of casting weight to production in lb/hr.

proceeds in its inevitable direction of higher rates and heavier castings, more attention must be focused on the cost of the metal. This can best be done by separating the metal cost into several principal components. These are:

a) Ingot cost.
b) Designed casting weight.
c) Melt loss.
d) Die, machine and operator factors affecting die blow.

METAL COST SAVINGS CONNECTED WITH INGOT COSTS

Since the market price of metal affects all suppliers of die castings alike, it may appear that little can be done by the individual die caster to improve his metal cost/selling price ratio. An all-out effort to buy ingot as cheaply as possible is not an adequate conception for treating the problem.

TABLE 2 — RELATION BETWEEN CASTING RATE AND METAL COST

Production Rate, lb/hr	Metal Cost, % of Total Costs
96	44.3
180	60.0
225	65.2
260	69.0
325	73.0
450	78.9
600	83.2
660	84.8

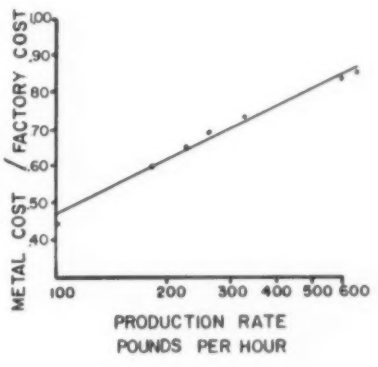

Fig. 2 — Relationship of metal content per unit of total cost to production rate.

The use of certain high-grade alloys in die casting, with the necessary subsequent down grading with addition agents to improve their die castability, can be avoided by judicious selection of alloy in the first place. A clear understanding of the effects on castability and properties of such of the normally present elements as iron, zinc, silicon, and others can be used to help purchase ingot at more favorable prices.

The burden of using the most economical alloy is on the die caster rather than the smelter or buyer of die castings.

In addition to the possibility of adjusting alloy specifications by mutual agreement with the customer, the die caster may improve his metal buying by the use of master alloy pig when combined with adequate alloying facilities and means for rapidly determining chemical composition. Freight savings by shipping castings out and returning ingot by the same truck offer cost savings in many instances.

Metallurgical inspection, including controlled checks for dross loss and nonmetallic content, should be routine.

METAL COST SAVINGS CONNECTED WITH DESIGNED CASTING WEIGHT

Close cooperation between the die caster and the product engineering department of the casting user has been the subject of extensive attention. It has also been pointed out as being an activity which the die casting business especially needs. In several recent meetings of the Society of Die Casting Engineers this was the principal subject. Here again it is the die caster on whom the large share of the burden falls. A carefully made casting drawing, spelling out wall thicknesses, drafts, finishes, tolerances, weight savers and possibilities of some revision in design, makes it necessary for the caster to understand the properties of the material he is working with. Also, it requires his familiarity with the end use.

Such things as minimum wall thickness, minimum finish allowance and no finish on holes which are tapped, require close understanding between supplier and customer. Closely held casting dimensions permit the use of minimum finish, but require good die construction and dependable machine operation.

METAL COST SAVINGS CONNECTED WITH METAL LOSS

The aim of the foregoing points is to reduce the metal content per unit. In addition to conserving metal in the end product, metal losses during processing are of great importance. Metal loss, if it is regarded as the difference between the weight of the ingot purchased and the designed weight of the casting sold, consists of:

1) Melting loss due to melting the ingot.
2) Melting loss due to melting the runaround scrap, including biscuits, runners, gates and finish.
3) Melt loss due to remelting scrap castings.
4) Loss of metal due to excessive weight of castings shipped. This is principally due to die blow.

The most important of the foregoing melting losses is in the dross loss due to remelting runaround scrap. Regardless of the method of melting, and assuming reasonably high quality ingot, the loss due to melting the required amount of ingot is secondary to the sum of the losses due to melting the unit scrap.

For this reason the unit yield of the net casting weight divided by the total weight cast, is of utmost importance.

In addition to making it necessary to have extra melting and metal handling capacity, there is a large overall effect of yield on melt loss due to rehandling of scrap. This is shown in Fig. 3.

The points on the curve in Fig. 3 can be obtained by using the following derivations.

If

L_m = Melt loss in pounds.
I = Ingot used in pounds.
W = Net Casting weight in pounds.

Then from a simple material balance,

$$L_m = I - W \qquad (1)$$

Since L_m is the sum of the unit melt losses incurred in melting the ingot and the runaround scrap, and if

L_i = Unit ingot melt loss (pounds per pound of ingot melted)
L_s = Unit scrap melt loss
S = Pounds of scrap melted

Then,

$$L_m = IL_i + SL_s \qquad (2)$$

Combining (1) and (2),

$$L_m = (W + L_m)L_i + SL_s \qquad (3)$$

The remelt scrap is equal to the difference between the total weight cast and the net casting weight. The yield is defined as the ratio net casting weight to total weight cast per casting.

If

Y = Yield.
C = Gross cast weight.

Then

$$S = C - W \qquad (4)$$

and

$$Y = \frac{W}{C} \text{ or } C = \frac{W}{Y} \qquad (5)$$

If (4) and (5) are combined,

$$S = \frac{W}{Y} - W \qquad (6)$$

Substituting (6) in (3)

$$L_m = (W + L_m)\,L_i + \left(\frac{W}{Y} - W\right) L_s \qquad (7)$$

From relationship (7) the melt loss in pounds per casting can be established (This can be expressed in pounds per pound of net casting weight by dividing L_m by the net casting weight.) Assuming a yield of 62.5 per cent, a unit ingot melt loss of 2 per cent and a unit scrap melt loss of 7 per cent, a typical calculation is shown below, substituting in (7)*

*R. Scmitt, "Die Metallverluste in der Spritz — und Pressgiesserei," *Metallwirtschaft, 22,* no. 18-20.

$$L_m = (1.0 + L_m)\,0.02 + \left(\frac{1.0}{0.625} - 1.0\right) 0.07.$$

$L_m = 0.0632$ or 6.32%.

L_m for other values of Y is shown in Table 3.

A family of curves similar to that shown in Fig. 3 can be constructed for any values for L_i and L_s which might apply in a particular plant operation.

The values L_i and L_s in themselves vary widely with the method used for melting and with the quality of ingot used. The character of the runaround scrap affects the melt loss quite drastically. Massive, dense scrap may have a unit melt loss only two to 2½ times more than good quality ingot, but thin, flaky and otherwise high surface area scrap may have a melt loss ten times the loss for melting ingot.

Expression (7) does not take into account the following three factors:

a) Casting efficiency.
b) Excess casting weight due to die blow.
c) Added remelt scrap weight due to die blow with a reduction in yield.

Other items not considered in expression (7) are processing losses such as machining, grinding or other finishing losses which are strictly additive.

To express the metal loss completely, taking the above factors into consideration, the melt loss L_m as determined by expression (7) must be divided by the casting efficiency, and the weight due to die blow must be added. The unit scrap weight increases by the amount of blow. Ingot weight also increases by the same amount.

If

B = weight due to die blow;
E = casting efficiency as the ratio good pieces/total pieces cast;
L = Total metal loss;

then an approximation for the total metal loss may be expressed thus,

$$L = \frac{L_m}{E} + B \qquad (8)$$

This approximation does not take into account the additional melt loss on the rejected castings, which are now heavier than they should be, nor the additional melt loss on the heavier unit runaround scrap.

In the example casting used to illustrate the application of expression (7), if the projected area of the casting is 50 in.² and the die blow is 0.010 in., then (using 0.1 lb/in.³ as the density of aluminum),

$$B = (50)\,(0.010)\,(0.1) = 0.05 \text{ lb or } 5\%;$$

and if E = 0.80 (80%) then;

$$L = \frac{0.0632}{0.80} + 0.05 \text{ or } 0.1291\ (12.91\%).$$

The drastic effect of both die blow and casting efficiency is illustrated by this example.

More exactly, since 20 per cent of the castings were remelted, (0.05) (0.20) or 0.01 lb must be added to S in determining the melt loss. Furthermore, if the 5 per cent weight added to the casting is also added to the original runaround scrap, then S becomes 1.05S. The melt loss for remelting the runaround scrap and rejected castings becomes (1.05S + 0.01)L_s, and can be so used in expressions (2) and (7). The added loss is on the order of 0.3 per cent.

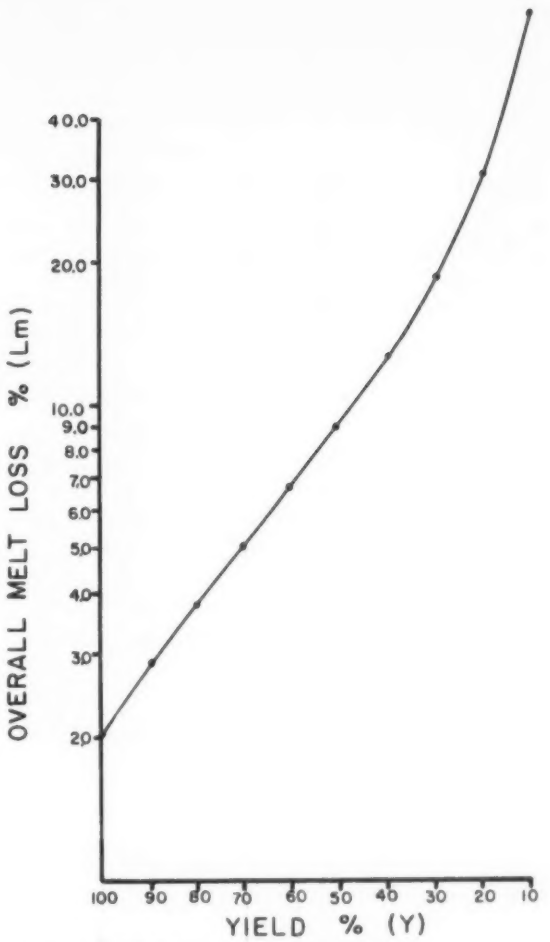

Fig. 3 — Melt loss as a function of yield.

SUMMARY

It has been demonstrated how dominating metal cost components have become in molten die casting practice. The following thoughts represent an orderly attempt at reviewing from a practical standpoint the specific factors on which the producer of

TABLE 3 — MELT LOSS AS A FUNCTION OF YIELD

Yield Net casting wt. Total Wt. cast/casting,%	Melt loss as % net casting wt.
5	133.0
10	66.4
20	30.6
30	18.7
40	12.7
50	9.2
60	6.8
70	5.1
80	3.83
90	2.94
100	2.04

die castings can profitably apply effort in order to control his metal costs.

Just as the productivity per unit of direct labor or return per unit of effort is important and has increased casting rates, so now can this same concept be important when applied to metal conservation. The objective is to get the greatest return in salable castings per unit of metal cost. These metal costs include not only material costs, but also those costs related to handling and conserving the metal. They go beyond the scope of normal foundry yield.

A review of the elements contributing to the costs represented by the four sources of metal costs previously listed should point out the areas where effort is required.

Ingot Cost

(This does not only involve simply beating smelter prices down)

a) *Sensible buying* against present and future market conditions as they can be appraised by the die caster.

b) *Using optimum alloys* from castability, customer acceptance and cost standpoints. The unquestioning acceptance of alloys as specified is a potentially costly and lethargic practice. The burden is on the die caster to determine the best alloy or its variations within or outside of specification ranges, and to work out customer approval for it.

c) *Form of receipt of metal.* Whether prime or secondary alloys, ingot or molten metal, or purchased scrap are used can be justified by the economic analysis appropriate to each operation, its location and type of product.

d) *Size of ingot* has an effect on purchased cost and on material handling cost within the plant.

e) *Freight* costs can be reduced frequently by carrying ingot instead of "dead heading" on return trips from delivering castings.

f) *Ingot quality* is a large factor where high performance, good machinability, close quality specifications or complex castings are involved. The presence of certain subtle but insidious factors, such as segregated intermetallic compounds and dross, can cause increasing metal costs even before foundry yields signal such rising costs.

Casting Weight

a) *Weight control as a concept* must be sponsored and encouraged by the die caster. Coordination between the product engineer, the die caster and the subsequent machining or manufacturing engineer is the starting point for exercising weight saving practices.

b) *Minimum wall thicknesses* must be used. Actual functional service requirements must be known, and excessive tolerances on wall thicknesses must be avoided.

c) *Die blow* or parting line flash must be minimized.

d) *Holes and weight savers* must be cored into the design. These not only improve castability, but frequently save subsequent operations.

e) *Match alloy to castability problems.* Frequently it has been possible to save metal in large amounts by the 0.010-in. or more reduction in walls made possible by increasing silicon content within the specification range.

f) *Die design* as it affects die blow, slide blow, parting line flash and washing out is important in weight control.

g) *Dimensional control* in the die makes thinner finishes for machining adequate. Reduced machining has the bonus advantage of not only saving metal, but of frequently eliminating flange facing and drilling before tapping. Holes and walls on location result in thinner walls and less finish.

Melt Loss

a) *The selection of the method for melting* and the inherent provisions for insulating the metal from an oxidizing environment have as much as a five-fold variation on losses. The type of temperature and atmosphere control, whether or not immersion melting is involved, whether gas or electric reverberatory melting is chosen, whether gas or resistance open pot melting is indicated or whether high or low frequency induction melting are chosen, are not only independently important, but must also be fitted into the composite aspects of the whole operation for best chance of reducing melt losses.

b) *Fluxing and refining techniques* are vital to conservation of metal.

c) *Casting efficiency, foundry yield, and flash* are particularly sensitive in their influence on melt loss. The volume of runaround scrap generated from these sources has considerable leverage on melt loss.

Die, Machine and Operator Factors Affecting Metal Conservation

The principal evidence of losses due to these influences is flashing. Miter and shut-off design which is accessible for die cleaning, lock design, drafts, cooling system, ejection and releasing features in the die design, control the tightness of locking and the losses due to metal escaping the cavity. In the machine, high locking pressures, good alignment techniques and practices and good maintenance are important for conserving metal. Operator vigilance in properly treating the above, as well as in keeping dies free of dirt, solder, abuse and uneven heating, show up in lower metal costs.

CONCLUSIONS

Since the die casting process for aluminum has developed into essentially a rapid transfer of metal through systems, the mechanization of which are in various stages of perfection, the most important economic factor now revolves around the cost of the working material flowing in the system.

The various aspects considered here can be best used if a detailed flow sheet is constructed for any operation, and the details peculiar to that operation are included. This and analyses built around it will serve as the most basic means for understanding and controlling the major cost of the operation.

DEOXIDATION DEFECTS IN STEEL CASTINGS

final report for the AFS steel division research committee

By R. A. Flinn and L. H. Van Vlack

ABSTRACT

Nonmetallic macroinclusions, commonly described as "snotters," are a frequent cause of scrap or lead to inferior machinability of the cope surface of steel castings (Mechanically entrapped sand and scabs are not included in this designation).

The three objectives of this investigation were to:
1) Identify these inclusions.
2) Trace their origin in foundry practice.
3) Suggest methods of elimination.

The results may be summarized under the same divisions:

Nature of Inclusions. In steel deoxidized with aluminum, the cope inclusions contain the mineral species corundum (Al_2O_3) surrounded by reaction products formed by later reactions between the corundum, the mold material, the metal and the atmosphere.

Origin of Inclusions. Detailed explanation is given to prove that the essential feature of the defect, the corundum, can only originate in the metal as a result of deoxidation with aluminum.

Methods of Elimination. Mechanical techniques of settling, skimming and trapping, as well as the use of complex deoxidants to form other deoxidation products, may offer solutions.

PREFACE

Considerable effort has been made in the last four years to identify the nonmetallic cope side defects found on steel castings. Since the results of this work throughout the cast metals industry were largely inconclusive, a fresh approach seemed necessary. Accordingly, the AFS Steel Research Committee sponsored work at the University of Michigan to identify these inclusions and to determine their genesis.

The results of this work are presented in the following paper. The committee feels that the steel foundryman should particularly note:

1) The positive identification of the defect.
2) The positive determination of the genesis of the defect.
3) The importance of the ceramist's polarizing microscope in phase identification of nonmetallic inclusions.
4) The necessity of retaining the surface sinter layer on castings in order to permit positive defect identification.

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INTRODUCTION

Review of the Problem

There is certainly general agreement regarding the importance of clean cope surfaces. Nonmetallic macroinclusions, called "snotters," are significant contributors to foundry scrap. Possibly more important, but less spectacular, is the serious effect of these materials upon tool life and in reducing endurance limit in fatigue. The latter consideration is particularly important with the recent emphasis upon high strength steel castings for aircraft applications.

It has long been recognized that proper molding, gating and risering lead to the elimination of other cope surface defects, such as mechanically entrapped sand and scabs. However, the "snotter" is somewhat reduced but not eliminated by these otherwise successful foundry practices. Therefore, it was selected as a subject for study by the Research Committee of the AFS Steel Division.*

Although this defect has been a source of great concern to production personnel, relatively little has been published concerning the problem. In most cases, castings are cleaned before inspection and it is then quite difficult to distinguish between the "snotter," mechanically entrapped sand, and even in some cases certain scabs, washes and drops. Sanders[1] has published a good description of the "snotter" defect, and indicated that a low melting eutectic slag from deoxidation might be the cause. He indicated further that this defect was still present in castings poured in graphite molds, thereby eliminating the variable of loose sand.

The following analyses of inclusions from castings were given:[1]

	From Sand Molds	From Graphite Molds
SiO_2, %	84	43
Al_2O_3, %	5	18
FeO, %	4.5	—
MnO, %	4.6	14
CaO, %	1	up to 18

Other discussions are generally fragmentary, but most shop sessions indicate the seriousness of the problem.

Based upon the available literature and many help-

*Present membership: A. J. Kiesler, Ex Officio, W. O. Igelman, C. H. Lorig, J. A. Rassenfoss, G. J. Vingas, S. C. Massari, Ex Officio and G. A. Colligan, Chairman.

Fig. 1 — Small snotter defect (Source 1). The only evidence before cleaning is the sand discoloration in the circled areas. Plate is 5⅜ in. x 6½ in.

ful personal communications, the objectives of this research were established as:

1) To identify the "snotter" defect in commercially produced sand castings.
2) Based upon the information of Sanders,[1] and a knowledge of the commercial production practices involved, to determine the origin of the nonmetallic inclusions.
3) To suggest means of reduction or elimination.

PROCEDURE

Samples Selection

Samples of "snotters" were provided through the co-operation of the four producers cited in the acknowledgment. The adhering sand was carefully protected during shipment so that the inter-relation between sand and casting would be evident. Details of manufacture were given with each sample, and in all cases aluminum deoxidation and silica sand molds were used. Samples of ladle riser scum were also submitted for examination to determine any inter-relation with the defect.

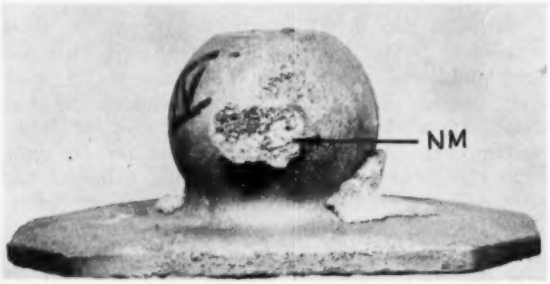

Fig. 2 — Large snotter defect (Source 2). Ball size is 4½ in. in diameter. Nonmetallic material (NM) has been shifted down to expose underlying metal surface.

Fig. 3 — Snotter defect of intermediate size (Source 3).

Examination Method

After receipt, the castings were photographed to illustrate the macroscopic appearance of the defects and then typical sections were cut, impregnated in thermal setting resin, mounted in thermoplastic resin and polished metallographically. The techniques are further described in references.[3,4] In addition, for optical measurement of birefringence and indices of refraction, powdered samples were studied with a petrographic microscope.

DISCUSSION

The results of the investigation may be discussed conveniently in the same order as the objectives, namely, the nature of the defect, its origin and suggested procedures for elimination.

Nature of Snotter Defect

Macroscopic appearance. The photographs of the samples submitted are reproduced in Figs. 1 to 4, inclusive. When a small defect is encountered, the only evidence is given by local discoloration of the adhering sand, Fig. 1. When the inclusions are larger, then a depression in the surface of the metal is encountered, Fig. 2. However, in all cases sand adheres to the inclusion as if a sintering or fluxing reaction is occurring.

Microscopic examination. The key feature of all the samples is the occurrence of the mineral corundum. It should be emphasized that the structures illustrated are not merely evidence of Al_2O_3, but of a particular crystalline species. The distinguishing characteristics are a hexagonal structure, high hardness and the optical characteristics of a uniaxial negative crystal of low birefringence with an index of refraction of $w = 1.76$ (the optical properties were determined by polarized transmitted light).

The corundum is visible as gray basal plates with

Fig. 4 — Snotter defect of intermediate size (Source 4).

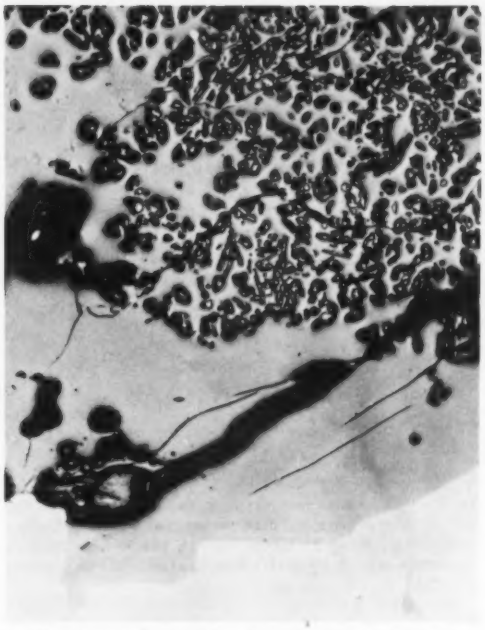

Fig. 5a — Cross-section through metal (bottom) and snotter (top). At top, corundum crystals in a glassy matrix are encountered followed by glass, and then the typical cast steel structure (Source 4). 100×.

Fig. 5b — Typical crystal outlines of the corundum in the glassy matrix are evident in this micrograph (Source 4). 500 ×.

the polishing characteristics of a hard phase in Figs. 5-9.

Other phases encountered in the inclusions may be summarized:

Glassy matrix (siliceous) – this noncrystalline substance surrounds the corundum crystals.

Quartz (SiO_2) – this is the form of most of the original sand grains.

Cristobalite (SiO_2) – sand reacts to form a glass from which cristobalite crystallizes. This is the stable form of silica in the temperature range 2680-3100 F; retained as it is cooled to ambient temperatures.

Magnetite (Fe_3O_4) is encountered in highly oxidized regions of the casting surface.[3]

Wustite (FeO) is present under less oxidizing conditions.

Fayalite (Fe_2SiO_4) is formed by crystallization during cooling from the liquid silicate glass formed at reaction temperatures.

Hercynite ($FeO{\cdot}Al_2O_3$) is a reaction product of iron oxide and corundum.

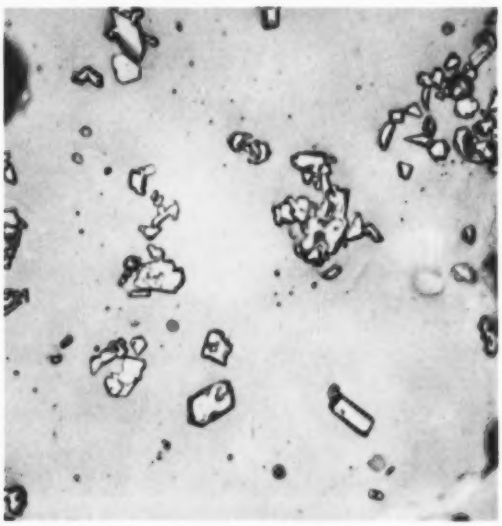

Fig. 6 — Detailed structure of snotter (Source 2) showing same structures as Fig. 5b, but greater solution of corundum by glass has reduced the amount and altered crystal outlines. 500 ×.

Fig. 7 — Detailed structure of snotter (Source 3) similar to Fig. 6, showing corundum. Metal (white) constitutes lower portion of photomicrograph. 500 ×.

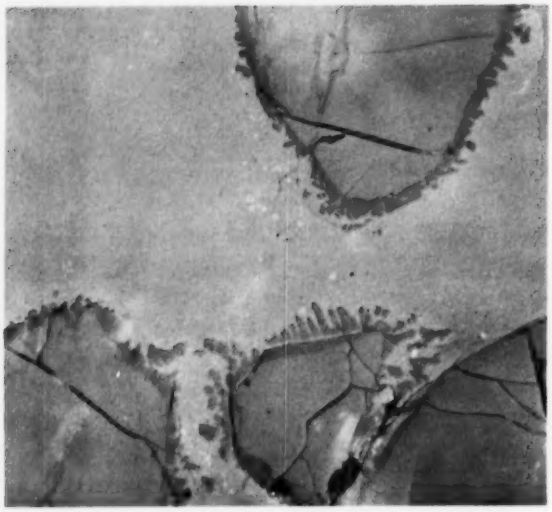

Fig. 8 — Sand grains with cristobalite fringes in glassy matrix (Source 3). Glass consists of SiO_2 dissolved corundum (Al_2O_3) and FeO. 500 ×.

The individual samples are discussed in the captions of the figures. Because of the minerals encountered, the variation in chemical analysis reported by Sanders can be better understood.

In summarizing, it can be pointed out that all the macroinclusions contained corundum accompanied by varying amounts of other minerals.

Origin of Ceramic Macroinclusions

In addition to providing identification of the defects, the petrographic analysis provides interesting information on the source of the inclusions. Corundum is not present in the molding material nor in the ladle refractories. The only logical origin is reaction of the aluminum added for deoxidation with oxygen dissolved in the melt. This is commonly encountered in steel ingots deoxidized with aluminum,[2,5] and many examples of corundum formation have been noted.

Therefore, the following sequence is proposed:

1) Reactions in the liquid metal, while in the ladle, and passing through the mold.

$$2\,\underline{Al} + 3\,\underline{O} \rightarrow Al_2O_3 \text{ (corundum)}$$

Some reaction of Al with FeO may also occur at the ladle surface.

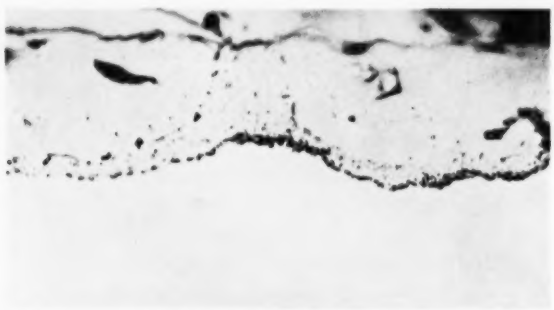

Fig. 10a — Iron oxide surface layer encountered in casting surface from all sources. 500 × (Source 3).

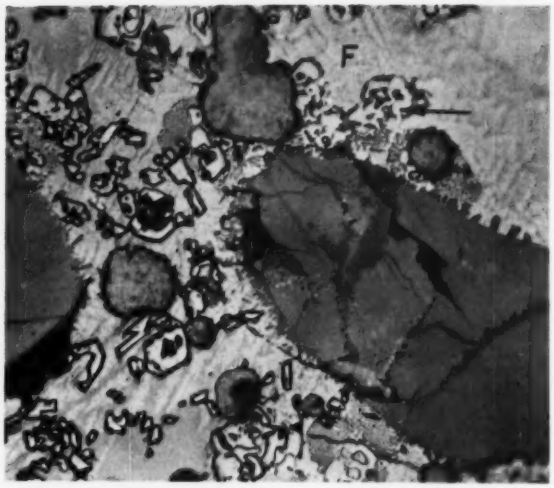

Fig. 9 — The corundum crystals have reacted with the FeO of the matrix to give a hercynite ($FeO{\cdot}Al_2O_3$) overgrowth (arrow). Upon cooling the excess FeO in the matrix combined with silica to crystallize as fayalite (F). 500 × (Source 2).

2) The surface of the corundum reacts with iron oxide forming a rim of hercynite.

$$Al_2O_3 + FeO \rightarrow FeO{\cdot}Al_2O_3$$

This reaction can take place in the ladle, metal stream or at the cope surface (Fig. 9).

3) Corundum reacts at the cope surface with silica, and iron oxide, to form a glass in addition to the hercynite reaction (Fig. 6).

4) Minerals crystallize from the glass upon cooling (Figs. 8, 9, 10b and 11).

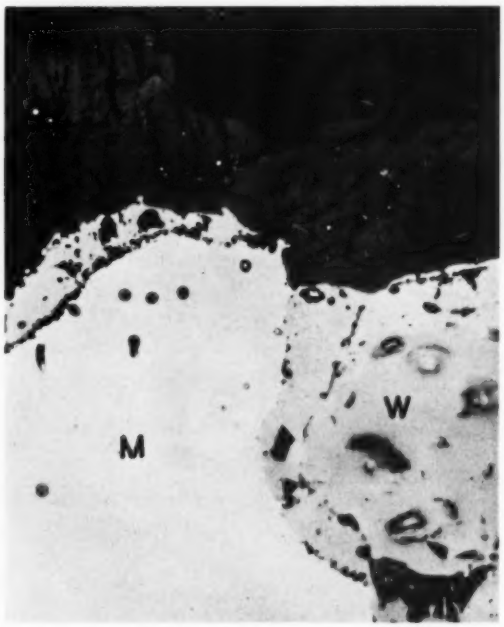

Fig. 10b — Reaction of iron oxide with silica sands. Metal (M), iron oxide (W), fayalite (F) and silica (very dark). Photomicrograph was printed darker than Fig. 11 to show contrast between iron oxide and metal. 500 ×.

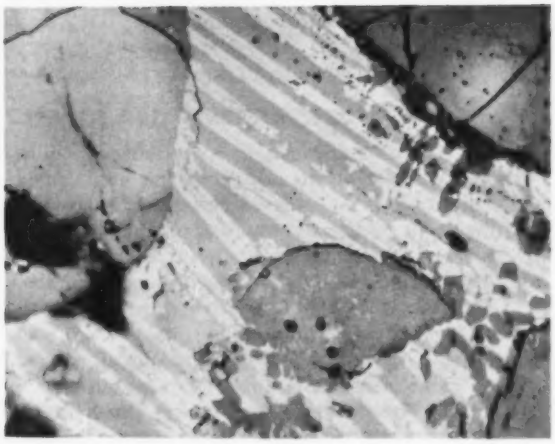

Fig. 11 — Fayalite (light plates) in glassy matrix, penetrating quartz grains. In this sample, as in Fig. 10, the fayalite formed during cooling. 500 × (Source 1).

glass Fe_2SiO_4, FeO, Fe_3O_4 and SiO_2
Fayalite Wustite Magnetite Cristobalite

Appreciable quantities of glass remain, as illustrated in the photomicrographs.

In Figs. 6 and 7 the fluxing of the alumina by silica (in particular) to form a glass is quite evident. By contrast, the regions richer in iron oxide (Fig. 9) contain hercynite and fayalite. The dendritic, idiomorphic crystals of fayalite indicate it formed after the reaction had ceased.

The specimen of ladle deoxidation scum shows the core of corundum being attacked by iron oxide to form the intermediate layer of hercynite (Fig. 9).

To summarize, the chief point is that corundum originates in the ladle as well as in the metal stream, and later reaction products are formed around it. This agglomerate reaches the cope surface and reacts further with silica and metal oxides.

It should be emphasized paticularly that the above sequence of events is proposed only for aluminum deoxidation.

SUGGESTED SOURCES OF ELIMINATION

Since the snotter is clearly related to deoxidation products, both mechanical and metallurgical methods of attack seem to offer promise.

Mechanical methods would involve improved gating systems, as suggested by Sanders.[1] An investigation of the rate of settling out of these inclusions in the ladle seems to offer promise. Obviously, if a metal is poured too soon after deoxidation, the trapped inclusions will not be filtered out by the gating and will rise to the cope surface.

Metallurgical methods would involve the study of alternative deoxidants and the resulting inclusions. The aggravation of the defect by reactions at the cope interface also requires study, since the greater the reaction the more serious the surface imperfection. The amount of aluminum or other deoxidant which is added should also receive attention. The aluminum remaining in the metal after deoxidation can react with either the mold atmosphere or with

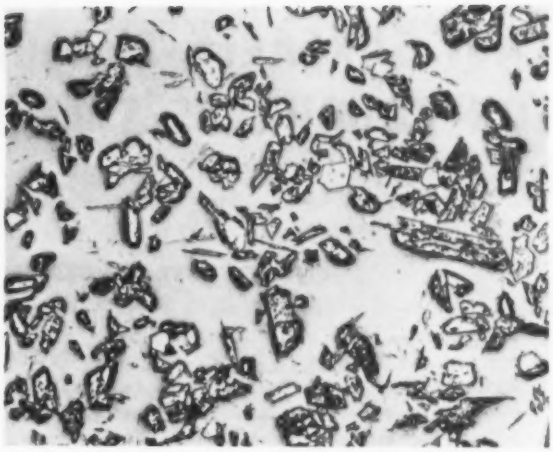

Fig. 12 — Deoxidation scum from receiving ladle. Corundum (Al_2O_3) is shown in glassy matrix identical to products found in cope surfaces of all castings. Some reaction occurred in castings between corundum and silicate melt. 500 × (Source 1).

oxygen from refractories forming additional corundum, which will probably be finally encountered at the cope surface.

CONCLUSIONS

The ceramic macroinclusions investigated here were corundum (Al_2O_3) associated with hercynite ($FeO{\cdot}Al_2O_3$), fayalite (Fe_2SiO_4), wustite (FeO), magnetite (Fe_3O_4), and a silicate glass.

Corundum is formed as a deoxidation product in the ladle (and in the metal stream passing through the mold when excess aluminum is present). Later reactions between corundum, iron oxide and silica result in the final formation of the macroinclusions. The defect is magnified by these mold-metal reactions.

Relief from this defect should be sought from mechanical and metallurgical techniques involving investigation of mold-metal reactions with other deoxidation products.

ACKNOWLEDGMENT

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In addition, the following companies contributed the material for the carefully prepared specimens mentioned in the text: Burnside Steel Foundry Co., Pelton Steel Casting Co., National Malleable & Steel Castings Co. and Wehr Steel Co.

REFERENCES

1. C. A. Sanders, "Casting Finish, Tolerance, Precision," AFS Transactions, *vol. 64*, p. 322, 333, 1956.
2. M. Baeyertz *Non-Metallic Inclusions in Steel*, A.S.M., 1947.
3. G. A. Colligan, R. A. Flinn and L. H. Van Vlack, "Effect of Temperature and Atmosphere on Iron-Silica Interface Reaction," AFS Transactions, p. 452, 1958.
4. Ralph Wells, L.H. Van Vlack and W. B. Pierce, "Reduction of Silica in Large Shell Molds," AFS Transactions, p. 459, 1958.
5. J. R. Rait, H. W. Pinder, "The Origin and Constitution of Certain Non-Metallic Inclusion in Steel," *J. Iron & Steel Institute*, June 1946.

CAST SURFACES EVALUATION FOR ROUGHNESS STANDARDS

By Eldon Swing

ABSTRACT

Developments in the casting industry have progressively produced cast parts with better quality, closer tolerances and smoother surfaces. The casting surface affects the measurement and function of the part. Methods of measuring machine surfaces are not applicable to castings. Foundry produced visual comparator gages for cast surfaces have been used with satisfactory results in many production applications, and have been generally accepted as the most practical method of controlling cast surfaces for the majority of casting applications.

A standard means of evaluating the surfaces of such a roughness gage has proved to be a major difficulty. However, before the use of the gage can be completely successful, it must be possible to standardize casting surfaces.

MIL-STD-10A specifies the mathematical method of evaluating surface roughness, requiring a profile view of the surface. In the method described here, this view is obtained by cutting a section through the surface. A photomicrograph of the edge is made and the surface evaluated by obtaining linear measurements in microinches from the photomicrograph. These linear measurements are then converted to roughness height rating (RHR) values by mathematical average.

It must be noted that this method is suitable only for evaluating a gage. The visual gage is to be used only for sight and feel evaluation. Since there is a wide latitude in the readings of a single surface, there should be sufficient tolerance associated with reading production surfaces to assure that microscopes, magnifying glasses or other aides are not necessary. Values used on a visual surface roughness gage shall be only those practical for visual comparison.

INTRODUCTION

Production engineering is based on standards and specifications which are followed by the design engineer. Most design engineers are not familiar with surface roughness requirements, but follow a manual in an attempt to meet specifications. The evaluation of surface roughness is included in Specification MIL-STD-10A, which is mandatory for military applications. The present practice of cast surface roughness evaluation avoids the exact requirements of this specification, while the photomicrograph method was developed as a means of fulfilling it.

CAST SURFACE ROUGHNESS STANDARDS HISTORY

Due to the nature of the casting process, and the use of various mold techniques and materials, all castings do not have the same surface roughness. When castings were included in the manufacturing processes of the aircraft industry, many factors, including physical specifications, changed in relative importance. At first, castings were rough shapes from which parts were machined, or further processed until they were suitable for aircraft use. The surface roughness was not critical because the contacting surfaces were to be machined. Remaining as-cast surfaces were considered basically for their appearance. Flaws and discontinuities could be repaired or sometimes filled.

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After a time the aircraft castings being produced were of such quality that the as-cast surfaces could, in many applications, be used as mating surfaces. With the acceptance of permanent mold castings in the industry at the beginning of World War II, efforts were made to control surfaces so that machining was eliminated. As experience in the molding processes accumulated, efforts were made to produce the raw castings to tolerances closer to the finished part requirements. Newer developments made smoother surfaces easier to produce. The application of casting was expanded. Sealing requirements, aerodynamics, contact of mating surfaces and stress and fatigue requirements became considerations. These considerations are affected by the surface roughness, therefore, the engineer was required to specify surface roughness.

Reason for Standards

When the engineer states a requirement on the drawing, the inspector must check each detail. When no standard is agreed upon between the producer and the user of the part, a difference of opinion can often cause rejection of entirely acceptable and functional parts. The resulting misunderstandings cause undue delay and extra expense.

It soon became apparent that a suitable method of evaluating cast surface roughness must be established. Surface roughness standards were already in use for machined surfaces. One type of gage, produced by typical machine processes, had been developed to identify various degrees of standard surface roughness. The success of the machine industry's

attempt at standardizing surfaces and identifying them propagated efforts to call out cast surface roughness using the same nomenclature.

SURFACE ROUGHNESS INSPECTION PROBLEM

The previously mentioned gage, universally used for machine surfaces, does not adequately portray the surfaces produced by the casting processes. The pattern of the surface has bearing on its identification. Integrating stylus-type machines developed to read machined surfaces take into consideration the direction of the pattern of the surface roughness. Since the surface roughness pattern of a cast surface has no direction, readings made with these instruments are not reliable. Regular dial indicator instruments are not adaptable. Nevertheless, the engineer continued to use machine surface roughness standards for casting designs expecting all the requirements to be met.

No inspection organization was exempt from the problem of insufficient standards. Since no yardstick was available for cast surface roughness measurements, the only positive way to determine whether or not the part would meet functional requirements was to make a sample supply of parts and evaluate them on an individual basis. This is costly and time consuming. A need for a standardized gage was recognized by both the foundry and aircraft industries.

Visual Gages

Some foundries produced visual gages which were suitable for their operation, and which appeared suitable for use in the aircraft industry. These gages were readily available, simple and low in cost. Surface evaluations were made by their actual use in the aircraft plants. Engineers of the author's company introduced such a gage into their plants in 1953. Foundry engineers, together with liaison engineers and inspectors of the aircraft industry, closely observed the use of this gage.

After a trial period, it was determined that the visual gage met the requirements of the industry better than any gage previously tried. When initial instruction in the use of the gage was given, differences of opinion were negligible. The use of a visual-cast surface roughness gage has, therefore, won universal approval.

Visual Gage Standardization

Even though this system has won universal approval, the evaluation, qualification and control of the many varieties of cast surface roughness gage has not been established. Several projects to provide standard visual gages are underway, and methods of standardizing these gages are under study.

Several paths are available for the establishment of a reproducible visual master gage. One means is to provide large sample plates from which small samples may be cut to make duplication masters. These original samples would be of sufficient number to supply industry needs for some length of time. This method is impractical. A second method is to provide a synthetic surface so hard that no wear would be apparent, and to make visual comparisons of these surfaces from time to time against small duplications.

Specifications for checking these duplications have never been defined in a suitable manner. This method also is impractical. A third plan is conceiving a means of reading cast surfaces within a specified tolerance, which allows the reproduction of a cast surface and the evaluation of its roughness. This plan is the basis of the method herein described.

MIL-STD-10A REQUIREMENTS

It has been standard industry practice to identify surface roughness values in root mean square (RMS) microinch units. The military requirement, MIL-STD-10A, identifies the averaging method values in roughness height rating (RHR) microinch units. Numerically, roughness height ratings are always of a lower value than root mean square values. The ratio, where close accuracy is significant, is approximately 11 per cent, and this value may be used as a conversion factor.

MIL-STD-10A identifies the basic evaluation of surface roughness as shown in Fig. 1.

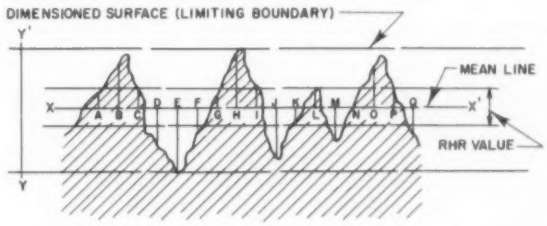

Fig. 1 — Specification MIL-STD-10A basic evaluation of machined casting surface roughness.

This specification applies to either machine or cast surfaces. In the words of this specification:

> "It shall replace all former practices for specifying finishes or surface conditions, and shall apply to any surface of sufficient hardness to be evaluated in terms of microinches under the provisions herein specified."

The mathematical evaluation is stated as follows:

$$RHR = \frac{1}{\ell}\int_{x=0}^{x=\ell} |Y|\,dx$$

An approximation of this value may be obtained by adding the Y increments without regard to sign, and dividing the sum by the number N, of the increments taken. This approximate summation formula is suggested in MIL-STD-10A:

$$RHR = \frac{A+B+C+D+\ldots}{n}$$

A true profile view of the surface is required to obtain the mathematical evaluation of A, B, C, D, etc. There are three means of obtaining this profile view. First, an electronic tracer may be used which graphs a simulated profile as a pointer is moved across the surface. This machine plots an enlarged

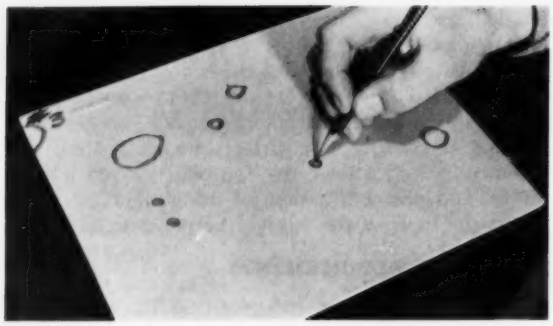

Fig. 2 — Defects in the surface were marked so they could be excluded in the sample selection.

graph of the surface as portrayed from a probe. A second method for duplicating the profile view is the use of a mechanical device. This method employs either a pantograph system, or a micrometer height gage instrument.

The pantograph system plots a graph in an enlarged view similar to the electronic tracer. The height gage spaces and reads heights directly at predetermined intervals. Both of these instruments are affected by the size of tracer point, and they also tend to scratch or mark surfaces.

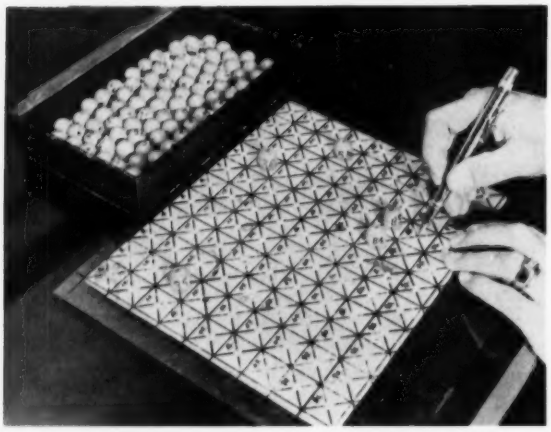

Fig. 3 — Specimen area was identified by marking the selected location through a small hole in the transparent grid.

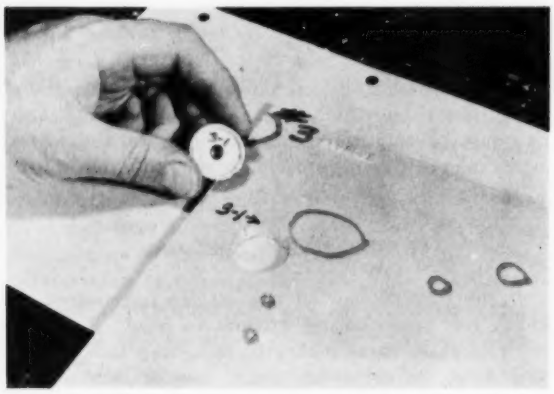

Fig. 4 — Samples cut from the plate were identified as to plate number and location.

PHOTOMICROGRAPHIC TECHNIQUE

A third method, the method reported in this paper, is the use of photomicrographs taken of a cross-section view. The photomicrographs must be carefully produced. The detailed procedure for producing these photomicrographs is:

1) Obtain sample cast plates of approximately a 9 in. x 11 in. area.
2) Identify the plates for subsequent checking as to their production process.
3) Examine the surface area to be checked visually for consistency. Any area which shows defects, either from the casting process or from subsequent handling, is marked so that it can be excluded in the sample selection (Fig. 2).

A random selection system based on probability principles was used, consisting of a transparent grid of numbered 1-in. squares laid out on a sheet of clear plastic. Numbers corresponding to numbers on the transparent grid were printed on wooden beads. The beads were placed in a box of sufficient size to allow mixing, and the transparent grid was laid over a sample plate. Five numbered beads were selected at random from the box.

The specimen area was identified by marking the selected location on the sample plate through a small hole in the center of the grid square with the corresponding number (Fig. 3). This location centered a 1-in. diameter hole saw. Five 1-in. circular pieces were cut from the sample plate by the hole saw, and each sample was identified as to the plate number, and its location on the plate (Fig. 4).

One area of the side of each of these samples was then ground to give a flat edge approximately ½-in. across (Fig. 5). No preference was given to a particular area. The samples were then given an electroless nickel coating 0.002 in. thick. This coating does not change the original surface of the sample, but adds a protective layer for subsequent processing.

Each sample was mounted in a bakelite button of a type used for metallographic studies. After mounting, the sample was polished in the same manner as though metallographic studies were to be made. No etching of the final polished surface was necessary.

A 500 × photomicrograph of each sample was taken using a standard machine. Care was taken that the view was a true edge view. The photos were

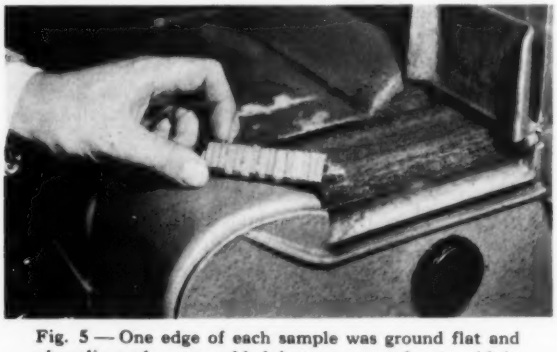

Fig. 5 — One edge of each sample was ground flat and phenolic pads were added between samples to aid in alignment and edge protection.

Fig. 6 — Photomicrograph shows the sample surface. White arrow points to the dividing line between the casting and the electroless nickel plating 0.002 in. thick used for protective purposes. 500 ×.

printed on glossy paper, and were the medium on which the linear measurements were taken. The 500 × photo, Fig. 6, brings out the dividing line between the surface and the plated layer with sufficient sharpness for taking measurements.

Most previous industry evaluations of surface roughness have been made using an 0.03 in. roughness-width cutoff value. The 0.03 in. roughness-width cutoff has proved to be one which will include most of the coarse irregularities of the surface for surface roughness values up to 500 RHR; therefore, this standard was used when obtaining the readings reported herein. Photos were spliced as necessary, because the equipment would not provide a single picture of the required 15-in. length.

A mean surface line was estimated using the 15-in. cutoff length on the photo to establish a basic direction of setup and measurements. Referring to the basic evaluation diagram, increment measurements of deviation from the mean surface, A, B, C, etc., are taken perpendicularly to the estimated mean line at 1-in. intervals.

A telereader was used to take the actual measurements. This device eased handling, and reduced human error incurred in reading scales. The machine consists of a lantern projection device wherein the image is projected twice size on a ground glass reading screen. Horizontal and vertical cross hairs are provided. An electrical counting device provides 854 increments of measurement per inch of movement of each cross hair.

Readings are taken by hand positioning the cross hairs and recording the position by an interconnected IBM computer. This provides data which are easily referred to. Sixteen readings were taken on each sample; a total of 80 readings were taken per sample plate.

RHR COMPUTATIONS

Using the previously stated summation formula taken from Specification MIL-STD-10A, and using the individual measurement readings as recorded by the digital computer, each set of readings was compiled on the basis of an 0.03-in. cutoff width. This was done by first totaling the measurements for each sample and dividing the sum by the number of readings. The results are the mean value.

The mean value then was subtracted from each measurement to get the deviation from the mean as indicated by the values A, B, C, D, etc. Each of these computed figures are again added, disregarding signs, providing a sum of the deviations from the mean value. This sum is divided by the number of readings giving an average value. Measurements and computations shown in the Table have been corrected for the 500 × magnification of the photomicrograph and converted to microinches. Values obtained are actual roughness height readings and are in accordance with the formula in Specification MIL-STD-10A.

ACCURACY EVALUATION

Based upon experience to date, it is felt that the five samples from each plate will give sufficient accuracy to indicate the RHR value of the entire

TABLE — COMPUTATIONS TO EVALUATE ROUGHNESS HEIGHT READING

Individual Measurement Readings		Deviation from Mean	
1	1838.4	A	295.8
2	1693.2	B	150.6
3	2105.4	C	562.8
4	2805.6	D	1263.0
5	2658.1	E	1115.5
6	1932.1	F	389.5
7	1740.1	G	197.5
8	1894.6	H	352.0
9	1391.1	I	151.5
10	1016.4	J	526.2
11	16.4	K	1526.2
12	1440.3	L	102.3
13	1084.3	M	458.3
14	1000.0	N	542.6
15	927.4	O	615.2
16	1138.2	P	404.4
	24681.6		8653.4

$$\frac{\text{SUM}}{\text{NOR}^{\bullet}} = \frac{24681.6}{16} = 1542.6 \text{ (Mean Value)}$$

$$\frac{\text{SUM}}{\text{NOR}^{\bullet}} = \frac{8653.4}{16} = 540.8_{\text{RHR}^{\bullet}} \text{ (Average Value)}$$

•Number of readings.
•(RHR) — Roughness height readings.

plate. A means is thus provided to certify the surface roughness of the plate, sections of which could be used as inserts for a visual surface roughness gage.

Variations in repeat readings of photomicrographs are within 10 per cent. Allowances for lens distortion in the photomicrograph machine, and other miscellaneous variations, indicate that the RHR readings obtained by the photomicrograph process will repeat within 15 per cent. The values obtained by this photomicrograph method were compared with other reading methods. There was a wide latitude between the photomicrograph readings and those taken with the integrating stylus-type instrument (profilometer). Readings were also compared with those taken by an electronic tracer machine which plots a graph.

The readings from the tracer-type machine compared favorably with the photomicrograph readings, but no conclusions as to the accuracy of this machine were attempted. Readings were also taken with a dial indicator-type instrument, and readings checked well in line with those of the photomicrograph method. Certain mechanical features of this machine were undesirable.

VISUAL GAGE LIMITATIONS AND UTILITY

Since the visual cast surface roughness gage has proved satisfactory for production use, the photomicrograph method is proposed for use only in evaluating and standardizing a visual gage. Some misunderstanding has been experienced as to the ability of the visual gage meeting the requirements of inspection. It is of major importance that education program data for the use of the visual cast surface roughness gage accompany the distribution of the gages.

Three basic rules will improve the utility of the visual gage. These are:

1) The visual gage should be used exclusively for a sight and feel evaluation, and shall not require microscopes or various reading devices to compare surfaces. Due to the tolerance allowances involved, no more accurate readings are feasible.

2) Often too much importance is placed on whether or not a cast surface meets the roughness specification. When it is difficult to visually determine that the production casting meets the surface specification, it would be equally difficult to prove that the surface would not adequately meet the functional requirement. The tolerance of the functional requirement is somewhat arbitrary. There is wide latitude in surface roughness readings over a so-called uniform surface.

3) Values used on a visual surface roughness gage should be those practical for visual readings. Cast surfaces smoother than 63 RHR may be measured by the means established for machine surfaces, and additional standards should not be required. When cast surfaces rougher than 500 RHR are permissible, it should not be necessary to check the surface roughness.

It is not the intent of this discussion to leave the impression that casting surface roughness is an insurmountable problem. Surface roughness should create practically no problems in the foundry. Cast surface roughness will probably always be a source of irritation for inspection and sales personnel. The information available to the engineer is being increased regularly, and no doubt he will be able to evaluate the surface he needs and will know what to expect from the foundry.

It is essential that the basic problem of creating a gage with accurate and practical values be achieved. Coordination between the foundry and aircraft industry should assure this ultimate goal.

ACKNOWLEDGMENT

The material presented in this paper constitutes many hours of work by supporting members of the Boeing Airplane Co., without whom it would have been impossible to cover the latitude of work required.

The Engis Equipment Co. and Tubular Micrometer Co. are also commended for their cooperation in supplying data and equipment for comparison readings.

POROSITY, INCLUSIONS AND PINHOLES IN MALLEABLE CASTINGS

By C. A. Sanders

ABSTRACT

An approach to the porosity, inclusions and pinhole problem in the malleable foundry is put forth. Inclusions are recognized too slightly as having a direct relationship toward the creation of pinhole porosity. Hot sand and brittle sand, in the author's opinion, are the most common sources of inclusions that may create pinhole porosity in production malleable foundries. Hot sands are believed to create a chain of reactions which become difficult to control. Other reasons for porosity or pinholes in malleable castings are those of improper melting practices. Also, mold wall movement tends to aggravate a surface pinhole condition.

MALLEABLE SCRAP CAUSES

There is no concrete agreement concerning porosity in malleable metal. Removing undesirable gases in malleable metal is a problem so complicated, and attached to so many theories, that one may easily develop strong arguments to support individual claims. Porosity is one continual difference of opinion supported by little evidence which has been proved on this foundry scrap problem. No single remedy works universally for all foundries. Many foundries do not have a standard definition concerning this scrap defect. Sand technicians have always carried a principal share of the blame, perhaps more than other departments.

Pinholes and gas porosity are not always associated with inclusions (Fig. 1). The inspection of the pinhole, or gas hole, is most important or they may incorrectly be identified as to cause. Inclusions may cause as many pinholes as entrapped gas.

In many malleable foundries inclusion porosity is linked with the scrap defect known as "dirt." The author is strongly against this nomenclature, as "dirt" generally indicates an inclusion (Fig. 2). If the inclusion cannot be identified properly, how can it be corrected? The inclusion must be slag, sand, refractory, carbides, sulfides, nitrides or dross from the products of combustion or oxidation, etc.; the word "dirt" must not be used in foundry nomenclature.

Since there are so many direct and indirect causes contributing to pinhole porosity, it is incorrect for one to make a positive statement that it is principally caused from a sand condition, or metal condition or by a specific department. There are too many cases in which the accuser of the sand department ends up the guilty party.

C. A. SANDERS is Vice-Pres., American Colloid Co., Skokie, Ill.

Usually, porosity originates from a collection of incorrectly applied practices, or incorrectly applied fundamental foundry laws. Even though slightly defective castings may be salvaged, the expenditure of time and materials to do so affects foundry profits. There is a series of combinations which may cause porosity, such as hot sands causing brittle sands which promote inclusions which develop pinholes.

It has been claimed that the number of operating factors that create porosity or gas defects usually is in excess of six. If an operation was constantly in error only 10 per cent, at the end of ten operations there could be a 100 per cent source of error.

It is often wise to invite service engineers to the foundry when difficulty arises, to determine whether

Fig. 1 — Typical gas porosity defect which appeared in the machine shop. Entrapped gas from some source is the cause of this scrapped casting.

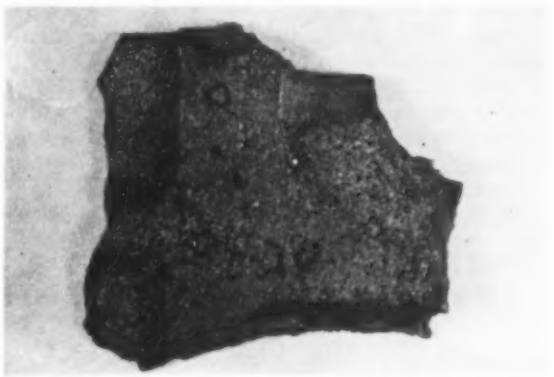

Fig. 2 — The word "dirt" does not properly identify the inclusion. Was this surface inclusion due to slag, sand, refractory or other source?

Fig. 3a — Inclusions may occur from skimmer cores. A soft, poorly prepared skimmer core may be the direct cause of sand inclusions.

or not the condition may be pointed toward sand, metal, ladles, melting practices or to other variables.

Many debates have been heard where the discussion of nonmetallic inclusions in oxidized metal was the issue. Surface oxides on the liquid metal must be trapped or skimmed, otherwise scrap may result (Figs. 3a and 3b). Metal furnace refractories erode easily under thermo-chemical activity, temperature, pressure and abrasion. The malleable foundryman is faced with the same problem as the steel foundry.

A new name is on the horizon, "ceroxides." These so-called ceroxides are thought to be products of combustion, and are low eutectic slags generally created during the deoxidizing period.

CERMETS

It has been found that certain pinhole fractures are associated with carbides and sulfide formations. In most cases the segregated areas are definitely dendritic, but tiny inclusions can also be seen at the base of the pinhole.

Numerous malleable castings have been studied that show manganese sulfide particles associated with stringy slag at the bottom of pinhole craters.

When the manganese sulfide inclusions are seen, the sulfur content is generally in excess of 11 points. Most malleable foundries use the formula for manganese content as twice the sulfur content plus 15 points. As the sulfur advances, so does the ferro-manganese alloy addition.

Many of the dark blemishes shown at higher magnification at the bottom of some dendritic fractures in malleable castings appear to be manganese sulfide inclusions associated with thin, stringy slag. The author has previously termed these "cermets." Some malleable foundries have stated that they now define this as a slag condition, and not as a pinhole gas defect.

Only by severe choking and gating the metal can this condition be eliminated. In some cases, the author has observed choking the malleable metal as little as 1 lb poured per sec to eliminate such surface inclusions.

DEFINITIONS

Experts have tried to define separately pinholes, porosity and gas defects.

Fig. 3b — Evidence that soft rammed and poorly prepared skimmer cores will cut any road in the area below the sprue.

Porosity is most generally associated with the internal wall structure of the casting. It may be caused by gas or steam passing through the metal, which may be accompanied by inclusions of nonmetallic material or dross (Fig. 4). Porosity may appear as a rounded cavity or as a dendritic structure; it is easy to confuse with metal shrinkage.

When the surface of a casting is pitted with small holes it is known as "pinhole porosity." Surface pinholing may indicate that the sub-surface metal may contain larger porosity or gas-hole areas (Fig. 5).

Gas holes are usually rounded cavities which appear spherical, flattened or elongated (Fig. 6). They vary in size and even in color, and are usually formed as smooth depressions rather than irregular surfaces.

Some investigators claim there are "evolution pinholes," which result when gas is dissolved in the metal and released because of lack of solubility with decreasing temperatures. They claim that "reaction pinholes" are caused by particles other than metal which form gas within the metal casting (Fig. 7).

Inclusions are recognized too slightly as having a direct relationship toward the creation of pinhole po-

Fig. 4 — Another surface porosity may be the direct result of gas passing through the metal accompanied by inclusions of nonmetallics or dross.

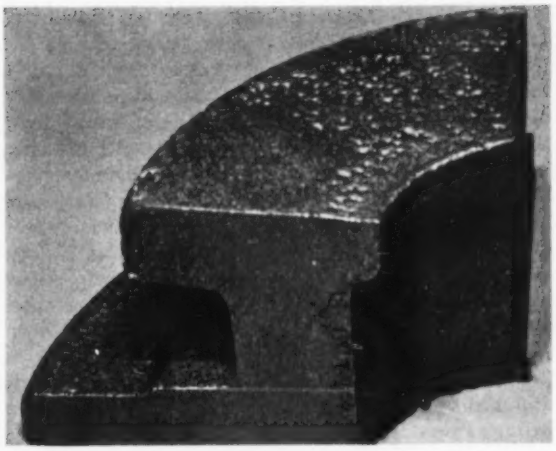

Fig. 5 — Surface pinholing may also indicate sub-surface enlarged porosity areas. Only by destructive testing can the areas be studied clearly and identification made properly.

rosity. It is the author's opinion that hot sand and brittle sand are the most common source of inclusions that may create pinhole porosity in production malleable foundries.

Hot sands are believed to be the chief influencing factor in pinhole porosity, setting into motion a chain of reactions that becomes too difficult to control, hence porosity and pinholes can occur.

Hot sands generally occur from lack of proper sand storage, and this is where the defect begins. To overcome hot sands, the foundry technician may use excess water or air to reduce the temperature (Table). Molding sands insulate themselves; therefore, it is common to find sands returning to the muller at temperatures exceeding 350 F. These sands consume gallons of water to reduce the temperature. If excess air is applied at the muller, the foundry has a chance of avoiding this defect. If there is not enough air to drive the steam from the saturated molding sand, an epidemic of pinholes can develop.

When excess water is applied to hot sand, the temperature is generally reduced to approximately 212 F

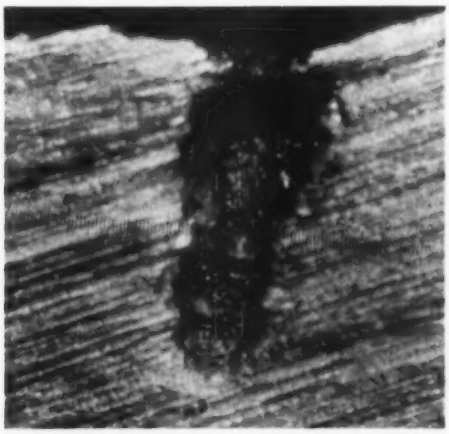

Fig. 7 — This pinhole may be called a "reaction pinhole," which may be caused from sand or other inclusions.

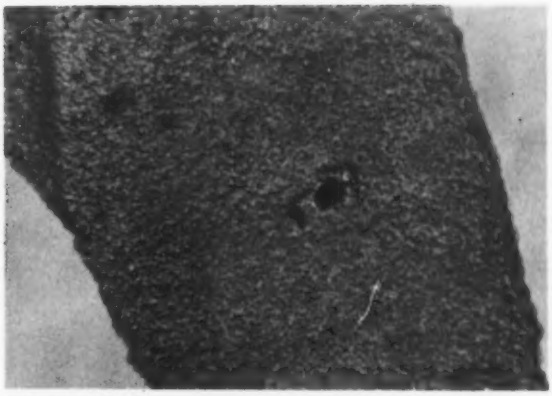

Fig. 6 — Many gas holes appear as cavities which may be spherical flattened or elongated, and may vary in size and color.

by conversion of water to steam. If a sand technician immediately tests sand at this stage, the laboratory temperature may show only 120 F, or perhaps less. The result is that as the sample is handled excess air is present; therefore, further cooling of the sample occurs which is not the exact condition of the sand when molded.

Actually, hot molding sand which has been decreased somewhat in temperature is still saturated with steam. When this steam-soaked sand covers the pattern and is jolted into place, numerous offending occurrences develop in the mold. Aside from sticking to metal patterns and sand handling devices in the foundry, it soon becomes the mold. The combination of metal turbulence in the mold and steam trying to escape, develops a brittle sand at elevated temperatures. Brittle sand rains sand grains onto the metal during pouring (Fig. 8).

Spalling of the sand grains can occur quite easily in a mold, which is one of the sources for inclusions, and may develop into pinholes as solidification progresses. Here is the perfect development of a pinhole. The same inclusion may be the direct cause, or hydrogen from steam in the hot sand may be carried directly into the metal by the molding sand, which rains into the mold as the casting is being poured.

TABLE — PROPERTIES OF MOLDING SAND

Properties	Molding Sand Temperature		Heated Sand Comments
	Room Temp.	160 F	
Green Properties			
Moisture content, %/wt.	4.0	3.6	Hot sand gives a variable moisture reading
Density, grams, 2 in. spec.	163	160	Penetration may result
Permeability number	75	75	
Mold hardness at 3 rams	91	91	
Compression strength, psi	14.0	12.1	more clay required
Deformation, in./in.	0.020	0.018	sand brittle
Dried and Fired Properties			
Dry compression strength, psi	150	100	loose sand inclusions
Hot compression strength, psi			
at 1650 F	160	80	
at 1850 F	100	60	thermal stability
at 2000 F	90	30	affected greatly

Fig. 8 — Hot sands become brittle sands, which in turn allow sand grains to wash with the inflowing metal.

Every foundryman has heard of "free moisture" and "combined moisture," but where there is an excess of water associated with an excess of bond there is always a danger of increasing the combined water. The combined water becomes an integral part of the bonded sand grain. If these fine bonded sand grains become dislodged and spall, they carry a considerable amount of mechanically combined water. When these grains are heated and converted to steam, the water expands 1600 times its own volume. The combined water then becomes a direct source for hydrogen and the chain reaction develops.

Hot sands develop faster in malleable foundries than gray iron foundries, since twice as much metal is poured by malleable foundries than gray iron per ton of salable castings, and the temperature of pouring is much higher. Management soon pays for hours of excess cleaning time, grinding time and excess labor due to this direct hot sand problem.

Scrap always increases when hot sands prevail with short mulling time. The author has seen scrap jump from a morning low of 3 per cent to as much as 37 per cent scrap in the afternoon due to the heating of the sands when it becomes unsatisfactory to mold.

Fig. 9 — Excess additions of coarse cellulose additives tend to make sand mixtures more brittle. Brittle sands cut and wash.

Ignoring excess scrap, high cleaning costs and rougher castings due to hot sands, management may be compelled to increase the use of corn flour where hot sands have created brittle sands in order to make it workable. The author has visited foundries that increased the addition of corn flour approximately one ton per day because of hot and brittle sand mixtures. Consider these additional corn flour costs at $125.00 per day, then how many days are required before that foundry has spent enough money to have purchased a cooling device, a second or third muller or additional storage bins?

It is quite probable that foundries with hot sands and short mulling cycles are required to use more cellulose products, bond additions and fine additions, with perhaps a second or third bonding agent to consume the large amounts of water necessary to overcome hot sands. This further enhances brittle, crumbly sands at elevated temperatures.

Hot Sand Effect

Brittle sands are most generally caused by hot sands. The excess water required in cooling hot sands is normally free water, unless an addition of cellulose is added to soak up these larger additions of cooling water. Excess additions of cellulose help control the excess cooling water (Fig. 9). As the sands tend to cool, the cellulose makes a more brittle sand mixture. As the sand mixture becomes more brittle it calls for more bond material, whether it be fire clay, bentonite or bond of any type. With the increased addition of bond, soon the end of the line has been reached as far as additions to the sand mixture can be made.

In many cases, when excess bond has been added to overcome brittle sands, it has become necessary to shorten the mulling time to some extent, otherwise the sands would become stiff and lack flowability.

If metal tonnage increases slightly then the only remaining solution towards furnishing sand promptly to the molders is by further shortening the mulling cycle.

Brittle sands are unstable at elevated temperatures. When metal enters the molds heat shock occurs, causing brittle sands to break and curl at the edges on the metal flow lines. Where this breaking and curling of the thin sand layer occurs, it will appear as a rattail or buckle on the casting (Fig. 10). The danger of this breaking and curling of unstable sands is the gathering of loose and free sand grains which mix with the metal as the mold is being poured. For this reason it is best to learn where flow lines of the metal occur over the face of the mold, and to disperse the gating system to avoid this phenomenon.

Malleable foundries with these problems would be better off perhaps if they added naturally bonded sand to maintain proper temper and bond. The naturally bonded sands do not require increased mulling as they possess some strength when added to the sand mixture. It is the author's opinion that naturally bonded sand added to hot sand, or brittle sands, is a better choice than to attempt to add a fire clay or bentonite and still shorten the mulling time.

When there is a large addition of core sand entering the system, so much bond is required to maintain strength that naturally bonded sands may be best for maintaining properties. It is not believed possible to rebond core sand entering the system without a sufficient mulling cycle. It is the author's opinion that unless a fire clay or bentonite is properly mulled into the system, more harm can be done than is recognized.

Hot, brittle sands are dangerous to each foundry that tries to force them to work by such efforts as described. At first, one claims a hidden success, then after some months an apology is usually made, and the fault is always pointed towards a particular raw material in the sand system. This is a regrettable error.

As larger castings or increased melting capacity occurs, the hot sand problem magnifies. Soon the mulling time is so shortened that it becomes only a mixing cycle where any bond would do the job (Fig. 11). The bond available to the foundry would probably work best. Under these circumstances all economies must be forgotten.

Bonding Material

There are cases where a certain bonding material has worked satisfactorily at a given foundry for as long as 10 or 12 years. Yet, after this foundry has grown in production and is confronted with hot sands, pinhole porosity or other gas defects, it wishes to blame the bond for the defect. Or, it may not be the bond accused but it may be the pig iron, the alloy, etc. The direct reasons, hot sands and short mulling time, are rarely accused.

Many foundries actually delight in stating that they have worked hot sands for years and have made them work. They state, "If they have worked in the past, why not in the future?" The medical profession has the answer to that one. Many people may live around a contagious disease for years and never catch it, but there is always a first time for this eventuality. Why take the chance?

As closer tolerances and improved casting finish are demanded by the customer, these hot sands will be corrected by the foundry. When machine shop scrap becomes out of reason due to under-surface porosity, that foundry may lose the pattern shortly.

One foundry that had molding sands so hot that molders were compelled to use gloves to handle flasks and patterns claimed they had no difficulty at these temperatures except for short periods at a time. They did not consider the amount of scrap being lost daily because of these hot sands. When it becomes necessary to heat patterns in order to get proper draws, sands are too hot to work.

The author has seen cases where hot sands have been so difficult to draw from the pattern that excess liquid parting was added. Consequently, these hot sands soaked up the parting as rapidly as it was applied (Fig. 12). One can recognize how much volatile gases were present at the mold-metal interface when the hot metal ran into the mold. Excess use of liquid parting is always dangerous, particularly when there are puddles in the various contours of the pattern. Hot molding sand picks up this liquid, and soaks it

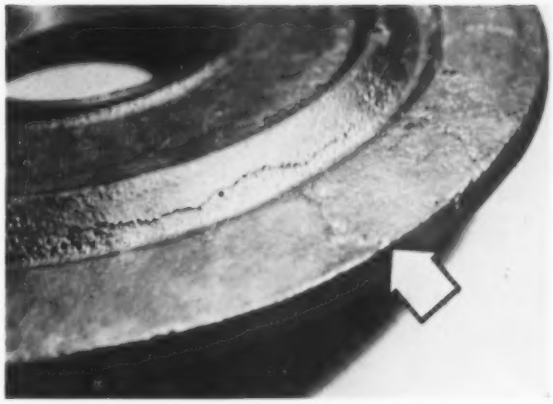

Fig. 10 — When metal enters brittle molds, the sand surface tends to break and curl at the edges of the flow lines. This will appear as a rattail or buckle. Loose, free sand grains follow the metal into the mold and are direct causes of inclusions.

up even more completely when these hot sands carry excess additions of cellulose and bond materials. Excess volatility is dangerous to good melting practice, and is a regular source of hydrogen gas porosity.

Here lies the confusion of malleable pinholes in most cases. Foundries will continue to resist the use of facings to overcome hot sands, but when facings become necessary the added cost will be accepted. They

Fig. 11 — Before condemning a foundry practice, determine the reason or reasons causing the defect. Which caused this one?

Fig. 12 — Mold gas can produce pinhole porosity. Excess liquid parting compound that produces volatile gas at the mold-metal interface may contribute to this scrap problem.

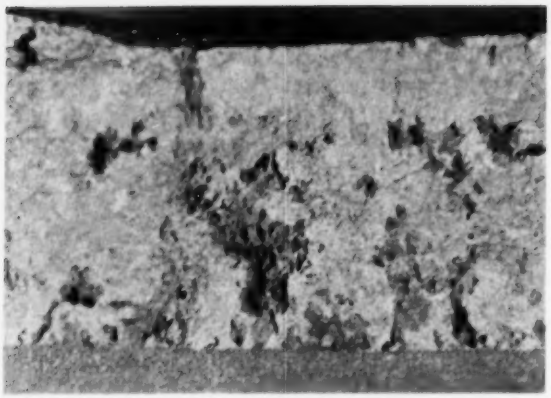

Fig. 13 — A typical spike defect. Graphitic hot tears appear on the surface when such pinhole porosity exists.

will continue to resist the suggestions of longer mulling times and the idea of purchasing an additional muller for the job. Foundries will argue against more sand storage or more aerating and cooling equipment, but will pay thousands of dollars in scrap due to this neglect.

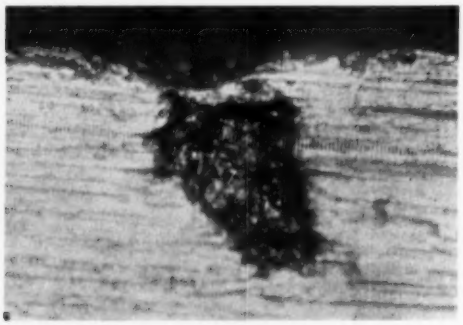

Fig. 14 — A pinhole which does not show on the surface except as a small depression. It will open upon annealing.

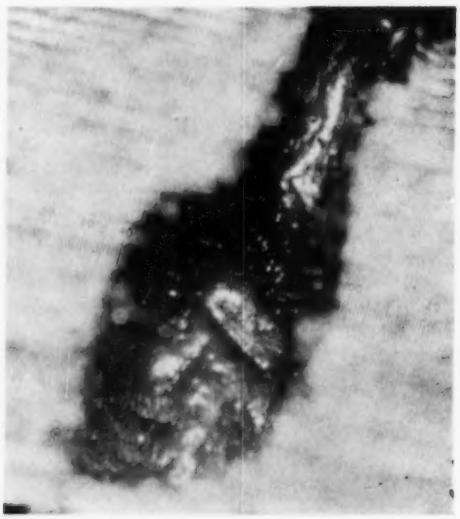

Fig. 15 — A pinhole. They may be round in shape and have an oxidized surface. They may appear in clusters just below the surface skin of the casting. 40 ×.

Management has lost track of why synthetic sands first entered the foundry industry; it was to maintain control and economy, and this involved the purchase of mulling equipment. If mulling capacity is too short to do the job, it is the author's opinion that management is paying the bill for excessive additives which normally would purchase mulling capacity and proper cooling and aerating equipment several times per year.

Management seems too inclined to want to purchase raw materials to add to hot sands to overcome their lack of workability rather than go directly to the source to overcome the problem. No doubt management shall continue to pay the bill for such scrap, but this bill when accepted is more likely to be lost or covered by other costs. Hot sands create a chain of reactions which become difficult to control.

There are many other reasons for porosity, or pinholes in malleable castings, particularly those of improper melting practices.

MALLEABLE MELTING CONTROL

Much of the surface pinhole porosity in malleable castings are termed "spears" or "spikes" due to their appearance (Fig. 13). Graphitic hot tears appear on the surface when this pinhole porosity condition exists.

This condition may occur in either a duplex operation or with a cold melt furnace. Larry Emery, Chief Met., Marion Malleable Iron Works, Marion, Ind., states that "the cold melt foundries which melt down charges very high in graphitic carbon run into pinhole defects quite frequently." Usually they incorrectly diagnose the cause of the difficulty as being sand. Only recently further detailed information has been accumulated to counter these claims. Many malleable heats from cold melt furnaces have not been properly super-heated and refined; thus the solidification temperature of the metal is changed (Fig. 14).

A slow rate of solidification permits gases which become entrapped in the casting to evolve. Nucleation is greater in malleable iron which is not properly refined, and pinholes may more often be present (Fig. 15). These pinholes are rounded in shape and have an oxidized surface. They may occur in clusters just below the surface skin of the casting.

Duplex Foundries

The duplex foundries encounter a similar problem if a proper oxidation loss is not maintained in both the cupola and air furnace. If a desired amount of oxidation does not occur, the pinhole defects may be predominant (Fig. 16). The defect shows immediately on vertical sidewalls of heavy sections near ingate and heavy riser areas. The responsible mechanics is the lowering of the solidification temperature, permitting the gases that are dissolved in the metal to come out of solution and become entrapped under the skin of the casting. In some cases the gas does get to the surface of the casting, and is entrapped at the mold-metal interface.

A good example of the above is in the casting of ductile iron. Solidification temperature is greatly re-

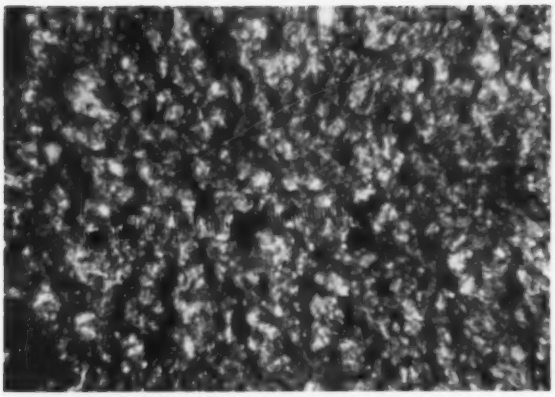

Fig. 16 — Small surface pinholes where the gas does not reach the surface before solidification occurs.

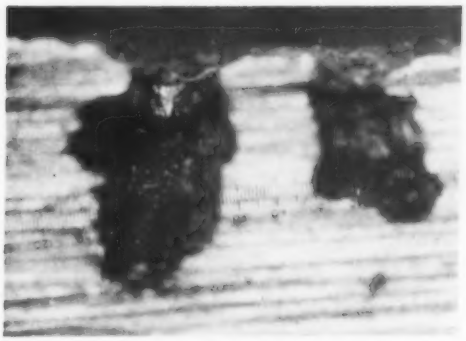

Fig. 17 — It is always difficult to analyze a surface pinhole. Inclusions must be magnified at least 40 × to be identified properly. If no inclusions are present, the condition may then be due to melting practices.

duced, and at these lower temperatures the gases present in the metal begin to work out of solution and may be entrapped on the surface of the casting (Fig. 17).

In an experiment reducing the sulfur content of a malleable metal, by reducing the sulfur to less than 0.06 per cent with soda ash, a considerable amount of pinholes developed. This was identified as a loss of temperature combined with excessive gas content in the metal.

In melting malleable iron, whether it is in a cold melt furnace or a duplex operation, it is important to maintain a minimum amount of oxidation loss. Reducing atmospheres in air furnace practice possibly are common faults in creating pinhole porosity.

Excessive additions of ferromanganese or ferrosilicon to white iron is a method of creating pinholes. If excessive additions reduce the solidification temperature of the metal being cast, pinhole porosity thus can be produced. The composition of the base metal in many cases is on the border line of producing pinhole porosity. If there is insufficient oxidation when the metal is being held in a reducing atmosphere, pinhole porosity may be magnified (Fig. 18).

Any addition of ferro-alloys that tends to reduce the solidification temperature of any metal prior to being poured should always be seriously considered, and must be viewed as a possible source of pinhole porosity. Atmosphere control in superheated or refining furnaces is now possible. The foundry continuous gas analyser records the combustion conditions in the superheat furnace. It is an important part of good melting practice to control the amount of combustibles in the furnace, as well as the introduction of excessive oxygen.

A practice that can easily influence pinholes is one that makes use of a reducing slag cover on the bath of malleable metal. It is important to keep the bath free from slag while the cupola is in operation, that is, if it is a duplexing operation. If the heat is prolonged, and it becomes necessary to use a cover slag, the degree of iron oxide in the slag must be kept to a predetermined level.

Many examinations of malleable pinholes at 250 × and 500 ×, unetched and etched with 10 per cent am-

Fig. 18 — A typical surface inclusion which has been termed "pinholes." It may be an inclusion or may be gas which has occurred from the inclusion.

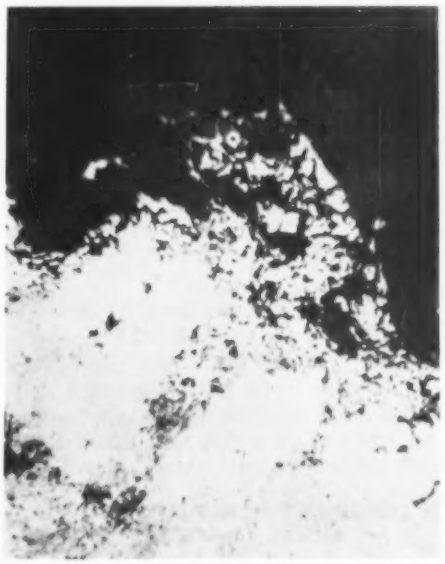

Fig. 19 — The area adjacent the pinholes is pearlitic. A filigree network of oxides containing primary carbides directly surrounds the pinhole cavities. There are some entrappd manganese sulfide inclusions, but not in all cases. The retention of carbides is due to the porosity and oxides. Manganese sulfide is not prominent or thought to be the cause of the pinhole.

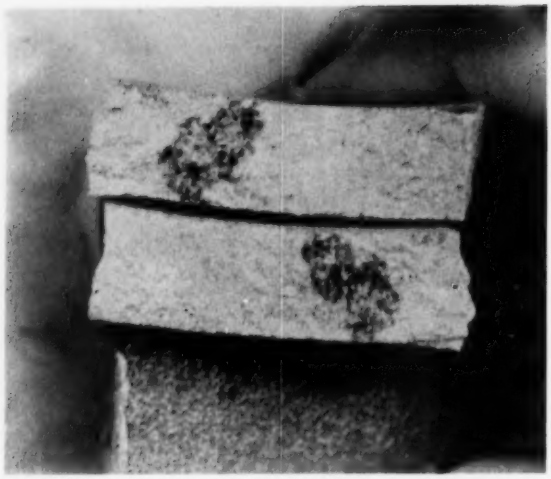

Fig. 20 — Some surface segregation areas definitely appear dendritic. The formation of carbide needles at the fractures may be due to hot spots on the surface or by gas seeping into cracks in the semi-molten metal. Gas may also occur from an inclusion producing hot spots that are dendritic.

monium persulfate, have revealed networks of oxides containing primary carbides directly surrounding the complete pinhole area (Fig. 19). In most cases there are areas of pearlite surrounding the oxide network. In some pinhole cavities small amounts of entrapped manganese sulfide inclusions can be detected, but not in all cases. Some pinholes appear to be associated with a complicated manganese sulfide and iron sulfide compound, which also have a network of "slag bond" at the surface of the pinhole. These the author has referred to as "cermet inclusions."

A duplex operator stated that it is better to pass from the cupola with a higher carbon rather than a lower carbon content, thus reducing the carbon content in the air furnace rather than at the cupola. For example, he states it is better to come from the cupola at 2.80 per cent carbon, than 2.60 per cent carbon if a 2.50 per cent is the end point. In the air furnace the 2.80 per cent carbon may be reduced to approximately 2.50 per cent carbon, whereas the 2.60 per cent cupola iron is already too close to the 2.50 per cent, which may force a practice of holding the heat with a reducing slag.

This synthetic slag used to block the heat is dangerous, and if a too reducing furnace atmosphere develops more centers of nucleation, primary graphite may be present. It is this primary graphite that causes the carbon rings on certain malleable castings, and these hot tear areas may also show the black spears or spikes common with certain types of pinholing.

MOLD MOVEMENT POSSIBILITY

Many times a gray iron or malleable casting may be oversize and overweight. This may encourage "apparent shrinkage." These surface segregated areas definitely appear dendritic (Fig. 20). The formation of carbide needles at the fractures may be due to hot spots on the surface created by this mold movement. Furthermore, the mold movement may tend to encourage hot tearing, which may further result in a dendritic structure.

Any movement of the mold tends to aggravate a surface pinhole condition, and certain malleable foundries are now aware that seacoal seems to minimize this unusual mold movement.

REFERENCES

Andrew, J. H., Lee, H. and Quarrel, A. G., "The Determination of the Solubility of Hydrogen in Iron and Iron Alloys," Iron and Steel Institute, Adv. Copy, Sept., 1942.

Adadurov, I. E., Pevnyi, N. I., Rivlin, I. I. and Kushta, G. P., "Absorption of Hydrogen by Chromium," *Trudy Kharkov Khim-Teknol. Insti. S. M. Kirova, vol. 1,* pp. 12-18, 1939.

Allen, N. P., "Experiments on the Influence of Gases on the Soundness of Copper Ingots," *Journal of the Institute of Metals, vol. 43,* pp. 81-124, 1930; also *Engineering, vol. 129,* pp. 457-461, 1930.

Ash, E. J. and C. M. Saeger, Jr., "Methods for Determining the Volume Changes Undergone by Metals and Alloys During Casting," AFA Transactions, *vol. 38,* p. 107, 1930.

Ash, E. J. and C. M. Seager, Jr., "Volume Changes of Cast Irons During Casting," AFA Transactions, *vol. 40,* pp. 172-200, 1932.

Batty, G., "The Most Potent Variable," AFA Transactions, *vol. 38,* pp. 309-331, 1930.

Boyles, A., "Influence of Atmosphere and Pressure on Structure of Iron Carbon-Silicon Alloys." *A.I.M.M.E. Transactions,* Iron and Steel Div., *vol. 135,* pp. 376-395, 1939.

Boyles, A., "The Freezing of Cast Iron," *A.I.M.M.E. Transactions,* Iron and Steel Div., *vol. 125,* pp. 141-203, 1937.

Baker, T., "Gases Occluded in Steel," Iron and Steel Institute, *Carnegie Scholarship Memoirs, vol. 3,* pp. 249-259, 1911.

Bohm, W. F., "Mold Materials Are Factors in Gray Iron Shrinkage," American Foundryman, *vol. 19,* no. 1, pp. 26-29, Jan., 1951.

Batty, George, "The Relation of Molds and Cores to Porosity in Steel Castings," AFA Transactions, *vol. 42,* p. 339, 1934.

Bardenheuer, P., and M. Kunkele, "Influence of Silicon Content and Cooling Rate on the Constitution of the Phosphide Eutectic in Cast Iron," *Mitteilugen,* Kaiser-Wilhelm Institute fur Eisenforschung, *vol. 12,* No. 4, pp. 33-38, 1930.

Benedicks, C., N. Ericcson, and G. Ericson, "Bestimmung des Spezifischen Volumes von Eisen, Nickel and Eisenlegierungen um Geschmolzenen Zustand," *Archiv für das Eisenhuttenwesen, vol. 3,* p. 473, 1930.

Caine, J. B., "A Method of Control of Oxides and Gases in Steel Castings," *Steel Foundry Facts,* pp. 2-11, May, 1940.

Chipman, J., and Murphy, D. W., "Solubility of Nitrogen in Liquid Iron," *A.I.M.M.E. Transactions,* Iron and Steel Div., *vol. 116,* pp. 179-190, discussion, pp. 190-196, 1935.

Caine, J. B., "A Method of Control of Oxides and Gases in Steel for Castings," Unpublished paper presented at round table discussion, AFA Convention, May, 1940.

Chipman, J., and Murphy, D. W., "Solubility of Nitrogen in Liquid Iron," *Metals Technology, vol. 2,* Jan., Tech. Publ. 591, 12 pp., 1935.

Dickie, H. A., *Journal, Iron and Steel Institute, vol. 159,* no. 4, p. 360, 1948.

Derge, G., W. Peifer and J. H. Richards, "The Sampling and Analysis of Steel for Hydrogen," *Metals Technology,* June, 1948, T. P. 2362.

Foseco Foundry Practice — Many copies *Technical Service* — Foundry Services, Ltd., England.

Gercke, E., "Experimentelle Thermische and Metallographische Untersuchung uber das System Eisen-Phosphor," *Metallurgie, vol. 5,* pp. 604-609, 1908.

Good, R. C., "Some Recent Developments on Iron and Steel Castings." *The Foundry, vol. 68,* no. 11, pp. 42-44, 103-105, 1940.

Goerens, P., and W. Dobbelstein, "Weitere Untersuchungen uber das Ternare System Eisen-Phosphor-Kolenstoff," *Metallurgie, vol. 5,* pp. 561-566, 1908.

Hultgren and G. Phragmen, "Solidification of Rimming Steel Ingots," *A.I.M.E. Transactions, vol. 135,* pp. 134-254, 1939.

Hayes, A., and Chipman, J., "Mechanism of Solidification and Segregation in a Low-Carbon Rimming Steel Ingot," *A.I.M.M.E. Transactions, vol. 135,* pp. 85-132, 1939.

Herasymenko, P., and Dombrowski, P., "Hydrogen Equilibria in the Production of Steel", *Archiv für Das Eisenhuttenwesen, vol. 14*, pp. 109-115, 1940.

Honda, K., and H. Endo, "On the Volume Change in Cast Iron During Solidification," *Science Reports*, Tohoku Imperial University, *vol. 16*, p. 19, 1927.

Honda, K., T. Kase and Y. Matsuyama, "On the Change of Volume of Cast Iron During Solidification," *Science Reports*, Tohoku Imperial University, *vol. 18*, p. 699, 1929.

Kempa, G. E., and R. W. Heine, "Effects of Some Melting Variables on Properties of Malleable Iron," AFS TRANSACTIONS, *vol. 63*, p. 19, 1955.

Kunkele, M., "Formation and Composition of the Phosphide Eutectic in Cast Iron," *Mitteilungen, Kaiser-Wilhelm Institut für Eisenforschung, vol. 12*, pp. 23-31, 1930.

Konstantinow, R., "Ueber die Phosphide des Eisens," *Stahl und Eisen, vol. 30*, pp. 1120-1121, 1910.

Klopf, Arthur S., "A Study of One Cause of Casting Defects," AMERICAN FOUNDRYMAN, p. 9, March, 1941.

Lange, E. A. and R. W. Heine, "Effects of Melting Furnace Atmospheres on Fluidity, Hot Tearing Tendency, and other Properties of Malleable Iron," AFS TRANSACTIONS, *vol. 60*, p. 169, 1952.

Lorig, C. H., and Samuels, M. L., "Some Effects of Hydrogen on the Time of Malleablization," AFA TRANSACTIONS, *vol. 50*, pp. 107-125, 1942.

Luckemeyer-Hasse, L., and Schenck, H., "Solubility of Hydrogen in Several Metals and Alloys," *Archiv für Das Eisenhuttenwesen, vol. 6*, pp. 209-214, 1932.

MacKenzie, *Pig Iron Rough Notes*, Winter and Spring, 1936.

McFerrin, W. B., "Casting Defects Common to Automotive Gray Iron," AFA TRANSACTIONS, *vol. 48*, pp. 1-30, 1940-1941.

McCabe, H. H., "Relationship of Chemical Composition & Mechanical Properties of Malleable Iron," unpublished M.S. Thesis, University of Wisconsin, 1953.

Marsh, J. S., *Principles of Phase Diagrams, Alloys of Iron Monographs, Engineering Foundation*, McGraw-Hill Book Co., New York, 193 pp., 1935.

Müller, F. C. G., "Ueber die Gasausscheidugen in Stahlgüssen," *Stahl Und Eisen, vol. 2*, pp. 531-542, 1882.

Martin, E., "Consideration of the Question of the Absorption of Pure Iron and Several of Its Alloying Elements for Hydrogen and Nitrogen," *Archiv für Das Eisenhuttenwesen, vol. 3*, pp. 407-416, 1929.

Pourcel, A., "Notes on the Manufacture of Solid Steel Castings," *Journal Iron and Steel Institute, vol. 22*, pp. 509-533, 1882.

Pearson, T. F., W. A. Baker, and F. C. Child, "Gas Porosity in Nickel Silver Castings," *Foundry Trade Journal, vol. 85*, No. 1667, pp. 145-152, Aug. 12, 1948.

Principles Involved in the Making of Rimming Steel, Iron & Steel Inst., "Fourth Report on the Heterogeneity of Steel Ingots," pp. 68-99 (See page 88), 1932.

Rosenthal, Philip C., "Ferrous Metallographic Practice", AFS TRANSACTIONS, *vol. 64*, p. 709, 1956.

Rote, F. B., "Phosphorus in Nickel-Molybdenum Gray Cast Iron," Ph.D. Thesis, University of Michigan, Jan., 1944.

Report — "A Defect Peculiar to Malleable Castings" — *Giesseripraxis*, 58.245, June 20, 1937.

Rote, F. B., and W. P. Wood, "Segregation of Molybdenum in Phosphorus-Bearing Alloyed Gray Cast Iron," *A.S.M. Transactions, vol. 35*, pp. 402-434, 1945.

Schenck, H., *Physical Chemistry of Steel-Making*, J. Springer, Berlin, *vol. 1*, 306 pp., 1932; *vol. 2*, 274 pp., 1934.

Swinden, T., and Stevenson, W. W., "Some Experiments on Gases in Iron and Steel and Their Effect on the Solidification of Ingots," *Iron & Steel Institute*, "Sixth Report on Heterogeneity of Steel Ingots," pp. 137-150, 1935.

Sims, C. E., "Preparation of Steel to Avoid Porosity in Castings," AFA TRANSACTIONS, *vol. 42*, pp. 323-338, 1934.

Saklatwalla, B., "Phosphoreisen, seiene Konstitution," *Metallurgie, vol. 5*, pp. 711-713, 1908.

Sims, C. E., "Why Deoxidizers Are Necessary," *The Foundry*, pp. 37, 109-111, Jan. 1941.

Sims, C. E. and C. A. Zapffe, "The Mechanism of Pinhole Formation," AFS TRANSACTIONS, *vol. 49*, pp. 255-281, 1941.

Sanders, C. A., and C. C. Sigerfoos, "Gray Iron Shrinkage Related to Molding Sand Conditions," AMERICAN FOUNDRYMAN, *vol. 19*, no. 2 pp. 49-55, Feb. 1951.

Saklatwalla, B., "Eisen and Phosphor, die Konstitution ihrer Verbindungen," *Metallurgie, vol. 5*, pp. 331-336, 1908.

Schwartz, H. A., Guiler, G. M., and Barnett, M. K., "The Significance of Hydrogen in the Metallurgy of Malleable Cast Iron," *A.S.M. Transactions, vol. 28*, pp. 811-829, 1940.

Stead, J. E., "Iron and Phosphorus," *Journal of the Iron and Steel Institute, vol. 58*, part 11, pp. 60-155, 1900.

Schneidewind, R., and C. Harmon, "Microstructure of Silvery Pig Iron," AFS TRANSACTIONS, *vol. 55*, pp. 602-606, 1947.

Sims, C. E., and Zapffe, C. A., "The Mechanism of Pinhole Formation," AFA TRANSACTIONS, *vol. 49*, pp. 255-270; discussion pp. 270-281, 1941.

Sieverts, A., "The Absorption of Gases by Metals," *Zeitschrift für Metallkunde, vol. 21*, pp. 37-46, 1929; Abstract, *Metallurgist, vol. 5*, pp. 168-172, 1930.

Sanders, C. A., "One Answer to the Snotter Problem," MODERN CASTINGS, May, 1956.

Smith, Eugene W., "A Solution to Pinholes," *Pig Iron Rough Notes*, Reprint — no date.

Timmins, A. A., "Shrinkage and Contraction of Cast Iron," *Foundry Trade Journal, vol. 59*, pp. 191-193, Sept. 15, 1938.

Timmons, G. A., "Theory of Shrinkage in Gray Cast Iron," *The Foundry, vol. 70*, no. 12, pp. 82-83, 1942; No. 1, p. 80, 1943.

Turner, T., "Volume and Temperature Changes During the Cooling of Cast Iron," *Journal of the Iron and Steel Institute, vol. 69*, p. 48, 1906.

Vogel, R., "Ueber das System Eisen-Phosphor-Kohlenstoff," *Archiv für das Eisenhuttenwesen, vol. 3*, pp. 369-381, 1929-1930.

Von Keil, O. and R. Mitsche, "Der Einfluss des Siliziums auf das System Eisen-Kohlenstoff-Phosphor," *Archiv fur das Eisenhuttenwesen, vol. 3*, pp. 149-156, 1929-1930.

West, W. and Hodgson, C. C., "Porosity and Sinking in Cast Iron," *Proceedings of the Institute of British Foundrymen*, paper No. 699, *vol. 32*, pp. 421-441, 1938-1939; discussion, pp. 442-448, 1938-1939.

West, W., "Phosphorus in Cast Iron," *Metallurgia, vol. 7*, pp. 83-88, 1933.

Wust, F., "Beitrag, Zum Einfluss des Phosphors auf das System Eisen-Kolenstoff," *Metallurgie, vol. 5*, pp. 73-87, 1908.

Zahn, Charles, "Porosity or Segregation in Gray Iron Castings," AMERICAN FOUNDRYMAN, p. 14, July, 1942.

Zapffe, C. A., "An Effect of Dissolved Gases on Casting Structure," to be published.

Zapffe, C. A., and Sims, C. E., "Hydrogen Embrittlement, Internal Stress, and Defects in Steel," *A.I.M.M.E. Transactions*, Iron and Steel Div., *vol. 145*, pp. 225-261, 1941; discussion pp. 261-271; *Metals Technology, vol. 8*, Technical Paper 1307, 37 pp., 1941.

LINEAR PROGRAMMING APPLIED TO ECONOMIC SELECTION OF MATERIALS FOR FURNACE CHARGES

By Gideon I. Gartner

ABSTRACT

Many combinations of furnace input materials exist which will meet a set of given furnace output requirements. The linear programming technique can be used to choose that feasible material combination whose material cost is a minimum. The technique can be used to calculate optimum prescriptions for individual heats, or to determine which materials to buy to stock in inventory. This paper is concerned with the "what to buy" decision; a hypothetical problem is solved on a high-speed digital computer, and several implications relating to the problem are discussed.

INTRODUCTION

At some point in the operation of a foundry, decisions must be reached which specify the particular furnace input materials (ferroalloys, bar stock, pig, etc.) to be purchased. The materials which are bought are eventually drawn from inventory, and melted together to form a product of some specified composition and gross weight.

It is unfortunately true that the decision concerning "what to buy" is often made without consideration as to the infinite number of possible combinations of different input types (drawn from the catalogs of the many furnace input producers) which will meet the specified requirements. How is one to choose among these many feasible combinations? Does a criterion in fact exist which allows these different combinations to be compared? Obviously, yes, since each feasible combination will generally involve a different overall material cost, and this cost should be minimized.

It will be shown that the technique called "linear programming" can be used to systematically evaluate the many possible combinations of inputs according to the least-cost criterion, thereby allowing the solution to the best-input-mix problem to be readily obtained.

LINEAR PROGRAMMING

Linear programming* has previously been successfully applied to "best mix" problems as described. For example, a Columbia economist has computed the least-cost mix of foods that a person could consume and yet meet all the accepted nutritional requirements; farms have applied the method practically in the determination of least-cost cattle feeds; and the petroleum industry in particular has realized substantial cost savings in applying L. P. (linear programming) to gasoline blending problems.[1,2,3]

In general mathematical terms, the technique applies to those processes or activities which are subject to a set of linear restrictions in the form of equalities or inequalities. If the number of feasible solutions within the constraints is large, L. P. can choose that particular solution among all feasible ones which optimizes an objective linear function.

Furnace Charge Application

The charging of metals in a furnace is an activity which fits the above description. One could wish to choose the least-cost mix of raw materials which, when melted, will give a product of known total weight and chemical composition. Since each raw material is of different composition, the linear restrictions are those which relate the contents of each chemical element in each raw material to the required content of that element in the end product. If X_i is the unknown weight to be charged of each raw material i, and P_{ij} is the per cent by weight of each element j in each raw material i, then

$$\sum_i X_i P_{ij} \left[\begin{matrix} \leq \\ = \\ \geq \end{matrix} \right] R P_j$$

where R is the total weight of the heat and P_j is the required percentage of element j. The equations represented by the above symbology are in fact element balances; some appear as equalities, for example the restriction that manganese content equal some specified amount; others appear as inequalities, e.g., the requirement that sulfur (an impurity) content shall be less than or equal to some specific limit. Others are also in inequality form, but appear as part of a two-equation set stating that the final content shall lie within a specified range.

There is another linear restriction which relates the weight of each raw material charged to the total weight of the heat:

$$\sum_i X_i = R$$

*The Appendix contains a geometrical explanation of linear programming for the interested reader.

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TABLE 1 — CHARGE MATERIALS INVENTORY

No. Corresponding to Materials Listed in Table 2	Materials Stocked in Inventory	Composition, % C	Mn	Si	Cr	Ni	Cost, $/lb	Lb Required in prescription per 1000 lb
2	FeMn	2.0	82.5	1.5			0.25	22.3
5	FeSi	0.15		50			0.20	23.4
9	FeCr	0.04		1.5	70		0.41	277.7
11	Ni	0.1				99.9	0.74	139.1
14	Pig	4.42	0.13	0.7			0.034	30.1
17	Generated Scrap	0.22	1.8	0.65	25	20	0	300.0
18	Stock	0.25	0.85	0.30	0.50	0.50	0.085	207.4

Total cost of 1000-lb prescription: $245.55

Still other restrictions appear in the metal-charging problem, according to the particular problem being solved. For example, one might limit the utilization of specific raw materials according to their availability. For example, if home-scrap is used, then the amount generated must limit the amount utilized.

The linear restrictions mentioned in the foregoing make up a set of simultaneous linear equations and/or inequations,* with the X_i's being the unknown variables. Linear programming extracts an optimum solution to the foregoing set of equations from an infinity of feasible solutions. The condition for more than one unique solution to exist is that the number of unknowns exceed the number of equations. It should be pointed out that whenever an inequality exists, an additional unknown is introduced which converts the inequality to an equality.

This unknown is called a "slack variable," since it is introduced to take up the slack (the extent of the inequality) between both sides of the equation (Appendix 1 clarifies the slack concept).

Once it is established that a great number of possible solutions exist, an "objective" linear function of the unknown variables (raw materials) must be set up to enable the L. P. technique to evaluate the many different possible solutions. Since the objective in this problem is the minimization of cost, a linear expression is constructed:

$$\sum_i X_i C_i = \text{Minimum}$$

where c_i is the cost per pound of the i^{th} raw material.

With the problem formulated, the L. P. computational procedure† is used to extract a solution. The procedure is iterative, requiring a systematic introduction of variables. As much of each chosen variable is brought into solution as the restrictive equations will allow, while amounts of other variables already in solution are adjusted. The method used to choose the variable being introduced at each step causes the results to converge toward a least-cost solution.

SOLUTION OF A TYPICAL PROBLEM

A steel manufacturer is producing S.A.E. 310 stainless steel with the following charged composition (furnace losses are added to the required composition, to give the charged composition):

Composition, per cent C	Mn	Si	Cr	Ni	P	S
0.25 max	2.00	0.75	24-26	19-22	0.03 max	0.03 max

*An inequation represents an inequality.

He carries in inventory the materials shown in Table 1, in which compositions and costs are listed. To meet the required end composition, and with the stipulation that generated scrap can contribute no more than 30 per cent of the total charged weight, a melter's calculation gives the prescription per 1000-lb heat shown in the right hand column of Table 1, at a total material cost per 1000 lb of $245.55.

The manufacturer wishes to know if he can reduce the average cost per heat by carrying a different set of raw materials in stock. He studies the market, and lists alternate materials to the ones being used. From this point, knowing the compositions and costs of the alternates, the least-expensive combination of inputs that will meet all the requirements can be found by L. P.

This was done for a total of 19 materials (listed in Table 2), including such alloy-rich metals as silicomanganese and ferro-chrome-silicon, two types of bar stock and several grades each of FeMn, FeSi, Cr, FeCr, Ni. The 11 equations (evaluating 25 unknowns) which are used in the L. P. solution are listed in Fig. 1. The equations are analogous to those symbolically represented earlier with a few additional refinements: each equation includes at least one slack variable with which is associated a high cost (M) in the objective function.

High Cost Slack Variables

These high-cost slacks are inserted for computational purposes only, and will be driven out of solution during computation, hence the name "artificial" slack variables. Equations a, c, d, f, g, h and i contain additional real slack variables, because these equations are in fact inequalities. The cost associated with real slacks is zero, and, ergo, these slacks do not appear in the objective function.

There are two equations written for the chrome balance, and two for the nickel balance. This is because requirements for these two elements allow a range of possible composition values. For each of these elements, one equation represents the upper limit (content to be less than or equal to x), and the other represents the lower limit (content to be greater than or equal to y).

A matrix of coefficients is constructed, and information from the matrix is encoded in machine language for the computer to operate on. Hand or desk calcu-

†Several algorithms have been developed to solve L. P. problems. The most widely used of these is the simplex technique, and the interested reader may learn the theoretical and computational details of this method from the literature.[4,5,6]

lator computation could be attempted depending on the size of problem, and for this a simplex tableau would be constructed.* For the particular problem under discussion, hand computation is infeasible.

The machine solution to this problem is shown in Table 3 which corresponds to Table 1, but lists the materials which L. P. says will, when combined, satisfy the requirements and restrictions at least cost. This least cost is $220.88, or about $24.00 saved per 1000 lb: ($48,000 per 1000 tons). The final cost is most sensitive to those materials used in greatest quantities. So if several other bar stocks were evaluated in the problem, a lesser-cost solution might well have been found.

In general, the more materials evaluated, the more likely are we to find a lower cost solution. There are two reservations to the above statement. First, it is entirely possible that certain materials can be eliminated from consideration by inspection (aside from those materials that will not even do from technological considerations). Second, it is assumed that no extra computational costs are incurred when more materials are evaluated. This assumption is a reasonable one, especially when the computation is by machine.

*The second half of the Appendix shows the simplex solution to a simplified problem.

FIG. 1 — EQUATIONS USED IN THE LINEAR PROGRAMMING SOLUTION OF THE LEAST-COST-MIX PROBLEM

A. DEFINITION OF TERMS

Let X_i represent the number of lb of input i used in the solution. Subscripts (i's) correspond to the numbers associated with the list of inputs in Table 2.

S_{jk} represent slack variables inserted for computational purposes in equation j.

M be a high cost associated with certain artificial slack variables, so that these "artificial" variables will be driven from solution.

R be the total weight requirement.

B. THE EQUATIONS

a) Carbon Balance

$$0.50X_1 + 2.00X_2 + 0.10X_3 + 0.15X_4 + 0.15X_5 + 0.50X_6 + 1.50X_7 + 0.10X_8 + 0.04X_9 + 1.0X_{10} + 0.10X_{11} + 0.25X_{12} + 0.75X_{13} + 4.42X_{14} + 0.05X_{15} + 1.5X_{16} + 0.22X_{17} + 0.25X_{18} + 0.13X_{19} + S_{a1} + S_{a2} = 0.25R$$

b) Manganese Balance

$$95X_1 + 82.5X_2 + 82.5X_3 + 0.13X_{14} + 66.5X_{16} + 1.8X_{17} + 0.85X_{18} + 0.50X_{19} + S_b = 2R$$

c) Phosphorus Balance

$$0.25X_1 + 0.35X_2 + 0.35X_3 + 0.05X_4 + 0.05X_5 + 0.06X_5 + 0.15X_6 + 0.019X_{14} + 0.03X_{17} + 0.04X_{18} + 0.025X_{19} + S_{c1} + S_{c2} = 0.03R$$

d) Sulfur Balance

$$0.10X_1 + 0.05X_2 + 0.05X_3 + 0.04X_4 + 0.04X_5 + 0.04X_6 + 0.06X_7 + 0.02X_{11} + 0.05X_{12} + 0.07X_{13} + 0.026X_{14} + 0.03X_{17} + 0.04X_{18} + 0.025X_{19} + S_{d1} + S_{d2} = 0.03R$$

e) Silicon Balance

$$1.0X_1 + 1.5X_2 + 1.25X_3 + 42.5X_4 + 50X_5 + 27.5X_6 + 16X_7 + 1.5X_9 + 1.5X_{10} + 0.70X_{14} + 43.5X_{15} + 19X_{16} + 0.65X_{17} + 0.30X_{18} + 0.30X_{19} + S_e = 0.75R$$

f) Chrome Balance, upper limit

$$96X_8 + 70X_9 + 70X_{10} + 37.5X_{15} + 25X_{17} + 0.50X_{18} + 3.5X_{19} + S_{f1} + S_{f2} = 26R$$

g) Chrome Balance, lower limit

$$96X_8 + 70X_9 + 70X_{10} + 37.5X_{15} + 25X_{17} + 0.50X_{18} + 3.5X_{19} + S_{g1} - S_{g2} = 24R$$

h) Nickel Balance, upper limit

$$99X_{11} + 98.9X_{12} + 97.7X_{13} + 20X_{17} + 0.50X_{18} + 1.6X_{19} + S_{h1} + S_{h2} = 22R$$

i) Nickel Balance, lower limit

$$99X_{11} + 98.9X_{12} + 97.7X_{13} + 20X_{17} + 0.50X_{18} + 1.6X_{19} + S_{i1} - S_{i2} = 19R$$

j) Equation limiting the scrap used to 30% of total weight

$$X_{17} + S_j = 30R$$

k) Total weight balance

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 + X_8 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} + X_{14} + X_{15} + X_{16} + X_{17} + X_{18} + X_{19} + S_k = 100R$$

l) The objective function (cost equation)

$$28X_1 + 25X_2 + 38X_3 + 24.2X_4 + 20X_5 + 17X_6 + 14X_7 + 131X_8 + 41X_9 + 37.5X_{10} + 74.2X_{11} + 73X_{12} + 71.6X_{13} + 3.4X_{14} + 33X_{15} + 14.5X_{16} + 8.5X_{18} + 10.5X_{19} + MS_{a1} + MS_b + MS_{c1} + MS_{d1} + MS_e + MS_{f1} + MS_{g1} + MS_{h1} + MS_{i1} + MS_j + MS_k = \text{MINIMUM.}$$

Further Cost Reductions

It is possible to reduce the average material cost per heat still further, although probably not to any great extent. The number of materials utilized in a prescription is limited in the L. P. procedure by the number of equations, or rows in the matrix of coefficients. The number of rows equals material inputs plus slack variables. If one slack variable could be driven out, an extra material input could be brought in, which might reduce the overall material cost.[7] A slack can generally be driven out by reducing a requirement coefficient by the amount of the slack which came out of solution, and recomputing.

This was done, and the new materials to be charged (8 in all, as against 7 before) are listed in Table 4. The new cost per 1000 lb is $219.21. If such a meagre cost saving (compared with the $220.88 prescription) is typical, the extra ordering and handling costs imposed by the extra input would negate the use of this last prescription, unless other considerations prevailed.

It is a fact that almost always materials exist which are substitutes for others. The L. P. method tests the economic suitability of using such substitutes. For example, in the last prescription a more expensive bar stock (No. 19) was chosen which, because of its rich alloy content, lessened the amounts prescribed of certain ferro-alloys. Thus, the final cost was still comparable (in fact less, because of the additional input allowed) despite the use of 341 lb of an "expensive" material. It often happens that utilization of the expensive input results in a cheaper prescription.

All L. P. computations were accomplished on an I.B.M. 650 machine. A linear programming canned program was available, which made programming the computer unnecessary. L. P. routines have been written for several of the available medium and large scale digital computers, and if the foundry does not own or share such a machine, the service bureaus of the larger computer manufacturers will make them available for a fee. Once again, an economic decision must be made before embarking on such a program. However, since for a machine comparable to the I.B.M. 650, the calculation lasts but a few minutes, and will be required several times a year at most, the computational costs are likely to be reasonable.

CONCLUSION

Those foundries which have a daily choice of charge inputs and a computer on hand might give some thought to the calculation of charges on a day-by-day basis. Even without a computer, there are successful manual techniques which have been developed, usually incorporating simplifications to ease the computational burden. Descriptions of these techniques can be found in the literature.[6,7]

The L. P. application described in this paper allows a foundry to make a choice of inputs to stock in inventory. The actual day-by-day charges will generally be calculated separately, unless day-by-day conditions are identical to those incorporated in the L. P. model. For foundries using L. P. to calculate the actual charges, D. E. Debeau[8] points out a limitation in the use of the technique: The composition of each charge input must be known within narrow limits. In those foundries where non-uniform purchased scrap is a major ingredient, L. P. is likely to prescribe a substantial amount of this low-cost scrap, which because of the variability of its composition will result in a relatively high number of off-heats.

A foundry may wish to know the best materials to

TABLE 2 — LIST OF THE 19 MATERIALS WHICH WERE EVALUATED IN THE DETERMINATION OF BEST INPUTS TO STOCK IN INVENTORY

Available Materials	Composition, %							Cost, ¢/lb
	C	Mn	P	S	Si	Cr	Ni	
1 FeMn	0.50	95.0	0.25	0.10	1.0			28.0
2 FeMn	2.00	82.5	0.35	0.05	1.5			25.0
3 FeMn	0.10	82.5	0.35	0.05	1.25			38.0
4 FeSi	0.15		0.05	0.04	92.5			24.2
5 FeSi	0.15		0.05	0.04	50.0			20.0
6 FeSi	0.50		0.06	0.04	27.5			17.0
7 FeSi	1.50		0.15	0.06	16.0			14.0
8 Cr	0.10					96		131.0
9 FeCr	0.04				1.5	70		41.0
10 FeCr	1.0				1.5	70		37.5
11 Ni	0.10			0.02			99.0	74.2
12 Ni	0.25			0.05			98.9	73.0
13 Ni	0.75			0.07			97.7	71.6
14 Pig	4.42	0.13	0.019	0.026	0.70			3.4
15 FeCrSi	0.05				43.5	37.5		33.0
16 SiMn	1.5	66.5			19.0			14.5
17 Scrap	0.22	1.8	0.03	0.03	0.65	25	20.0	0.0
18 Stock	0.25	0.85	0.04	0.04	0.30	0.50	0.50	8.5
19 Stock	0.13	0.50	0.025	0.025	0.30	3.5	1.6	10.5

TABLE 3 — MACHINE SOLUTION OF PROBLEM

No. Corresponding to Materials Listed in Table 2	Materials to Stock in Inventory	Composition, %					Cost $/lb	Lb Required in prescription per 1000 lb
		C	Mn	Si	Cr	Ni		
1	FeMn	0.50	95.0	1.0			0.28	9.3
16	Si-Mn	1.5	66.5	19.0			0.14	3.6
10	FeCr	1.0		1.5	70.0		0.375	64.1
9	FeCr	0.04		1.5	70.0		0.41	169.3
11	Ni	0.1				99.5	0.74	129.0
17	Generated Scrap	0.22	1.8	0.65	25.0	20.0	0.0	300.0
18	Stock	0.25	0.85	0.30	0.50	0.50	0.085	324.7

Total cost of 1000-lb prescriptions: $220.88

TABLE 4 — RECOMPUTING THE PROBLEM

No. Corresponding to Materials Listed in Table 2	Materials to Stock in Inventory	Composition, %					Cost $/lb	Lb Required in prescription per 1000 lb
		C	Mn	Si	Cr	Ni		
1	FeMn	0.50	95.0	1.0			0.28	9.8
16	SiMn	1.5	66.5	19.0			0.14	4.5
10	FeCr	1.0		1.5	70.0		0.375	121.7
9	FeCr	0.04		1.5	70.0		0.41	96.9
13	Ni	0.75				97.7	0.72	7.1
11	Ni	0.1				99.5	0.74	118.2
17	Generated Scrap	0.22	1.8	0.65	25.0	20.0	0.0	300.0
19	Stock	0.13	0.50	0.30	3.5	1.6	0.105	341.7

Total cost of 1000-lb prescription: $219.21

stock in inventory for a specific production schedule, or to meet a fluctuating demand. In the first instance the required chemical analyses for the individual company products can be pooled together, and the optimum raw-material mix to be stocked may then be calculated by L. P. The foundry may wish to recompute the optimum raw-material mix whenever there is a cost-change in one of the inputs, when there is a product requirements change, when new materials become available or periodically.

If the foundry employs economic lot-size formulas for the determination of stock quantities, a new prescription calling for substitute materials could not be put into effect until old materials are utilized. Therefore, the foundry might wish to standardize the inventory cycle* for all charge input materials, and calculate the optimum charge by L. P. at each cycle.† Whether or not such a standard cycle is used, depends on a cost analysis which needs to be undertaken.

In general, the total variable inventory cost for all charge inputs using the standard inventory cycle time, will exceed the total cost when each input is stored at its own optimum level. Before adopting a change in the inventory system, this extra expense must be compared with the estimated savings from linear programming prescriptions, and the convenience of ordering all charge materials together.

Since each application is individual, it remains for each foundry to determine if such methods as were described in this paper could be incorporated (inevitably with alterations) into their system to advantage. The systems analysis should be done carefully, lest some significant hidden cost or benefit be overlooked.

ACKNOWLEDGMENT

The cooperation of the I.B.M. Corporation during the computational phase of this program, is gratefully acknowledged.

*Ordinarily the inventory cycle is different for each material.

†It is assumed that the charge inputs represent a relatively small fraction of the foundries total purchasing volume, so that ordering all 8 inputs at once does not overtax the space available.

REFERENCES

1. A. Charnes, W. W. Cooper and B. Mellon, "Blending Aviation Gasolines – A Study in Programming Interdependent Activities in an Integrated Oil Company," *Econometrica, XX,* 2 (April 1952).
2. D. C. Lennon, "Operational Research: Its Applications to the Oil Industry," *Petroleum, 17,* No. 4 (April 1954).
3. G. H. Symonds, "Linear Programming Solves Gasoline Refining and Blending Problems," *Industrial and Engineering Chemistry, 48,* (March 1956).
4. A. Charnes, W. W. Cooper and A. Henderson, "An Introduction to Linear Programming," John Wiley & Sons, Inc., New York, (1953).
5. T. C. Koopmans (ed.), "Activity Analysis of Production and Allocation," Cowles Commission for Research in Economics, No. 13, John Wiley & Sons, Inc., New York, (1951).
6. O. R. Bibliography, "A Comprehensive Bibliography on Operations Research," Publications in Operations Research, No. 4, John Wiley & Sons, Inc., New York, (1958).
7. John Coakley, I.B.M. Corp., personal discussion (1958).
8. D. E. Debeau, "Linear Programming Isn't Always the Answer," *Operations Research,* (June 1957).

APPENDIX

Explanation of the L. P. Technique

Let us study a grossly simplified version of the metal-charging problem. Assume that a foundry must produce 100 lb of a product with specifications as follows: Percentage composition of element 1 not to exceed 0.05, element 2 not to exceed 0.07, element 3 not to exceed 0.07. Two raw material inputs called *A* and *B* are available, with element compositions and costs as specified in Table 5.

TABLE 5 – RAW MATERIAL INPUTS

Element	Composition of Input A	Composition of Input B	Max. Allowable content in end product
1	0.02	0.07	0.05
2	0.05	0.06	0.07
3	0.08	0.04	0.07
Cost ¢/lb:	5	4	
	100 lb required.		

Based on the given information, three inequations can be constructed, each inequation representing an element balance. These balances are the "linear restrictions" referred to in the body of the report:

Balance for

Element 1: $0.02X_A + 0.07X_B \leq 0.05(100)$ *(1)*

Element 2: $0.05X_A + 0.06X_B \leq 0.07(100)$ *(2)*

Element 3: $0.08X_A + 0.04X_B \leq 0.07(100)$ *(3)*

where X_A is the no. of lb of input *A* to be prescribed, and X_B is the no. of lb of input *B* to be prescribed.

Another linear restrictive equation can be written specifying that the total weight of the heat be 100 lb.

$$X_A + X_B = 100 \qquad (4)$$

Because expressions (1), (2) and (3) are inequalities, slack variables (S_1, S_2, and S_3) are introduced which convert the expressions to equations.

$$0.02X_A + 0.07X_B + S_1 = 0.05(100) \qquad (1)$$

$$0.05X_A + 0.06X_B + S_2 = 0.07(100) \qquad (2)$$

$$0.08X_A + 0.04X_B + S_3 = 0.07(100) \qquad (3)$$

$$X_A + X_B = 100 \qquad (4)$$

The slack variables increase the number of variables to five. Because only four equations can be written, a multitude of feasible solutions exists. These many solutions are evaluated according to the "objective function," which represents in this case the minimization of cost:

$$\text{Cost to be minimized (\$)} = 0.05X_A + 0.04X_B$$

The geometrical representation of the above problem is as follows:

In Fig. 2, let the ordinate represent lb to be used of input *A*, and the abcissa represent lb to be used of input *B*.

If we were to satisfy the element 1 requirements entirely with input *A*, we would require at most 5/.02 = 250 lb of *A* (5 is the max. no. of lb of element 1 re-

quired, 0.02 is the percentage of element 1 found in input *A*). If we were to satisfy the element 1 requirements with input *B*, we would require at most 5/.07 = 71 lb of *B*. The line connecting the 250-lb point for *A* and 71-lb point for *B*, represents the linear restriction written out previously as equation (1).

Any combination of inputs *A* and *B* described by a point on this straight line, will meet the maximum allowable requirement for input 1. Since this is a maximum requirement, the area enclosed by the two axes and this straight line represents the "feasible space." Any point within this area satisfies the first restriction.

Similarly, one can draw the restrictive lines for elements 2 and 3. These lines are properly labeled in Fig. 2. For each of these lines (restrictions), feasible space includes the triangle formed by the line and the axes. It can readily be seen that feasible space for the three restrictions when taken together includes only the area which is shown shaded in the figure.

There is one additional linear restrictive equation which must be considered [Equation (4)]. It says that 100 lb of input material must be used. There are no maximum or minimum limits here, exactly 100 lb are called for, and the straight line representing combinations of *A* and *B*, which total 100 lb, is shown dashed in Fig. 2. This line reduces feasible space from the shaded area to that portion of the straight dashed line which intersects the shaded area.

The problem now is to find the point along the feasible portion of the dashed line at which the foundry should operate; e.g., the most economical mix of *A* and *B* to use, while still satisfying all the restrictions which were set up.

One does this by plotting the objective function on the same graph. The dotted line shows the cost function describing a cost of $1.00. Any point on this line represents a combination of inputs *A* and *B* whose cost equals $1.00. Other cost functions are straight lines parallel to the $1.00 line. If one finds the line closest to the origin which just intersects feasible space, that line gives the lowest cost which may be obtained while satisfying the requirements.

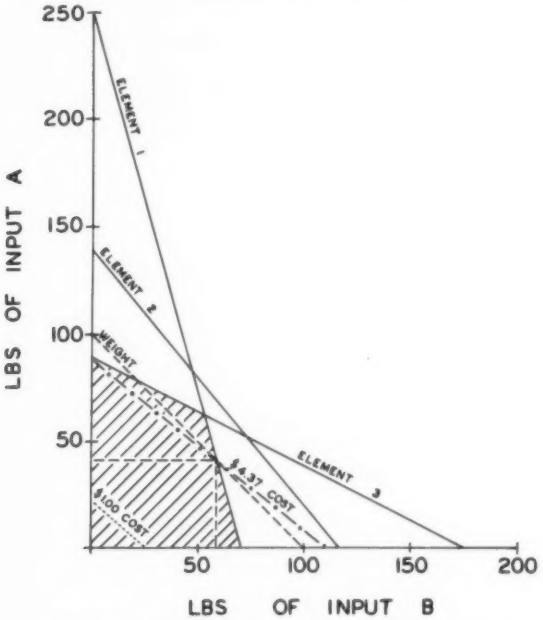

Fig. 2 — Geometrical representation of the linear programming problem.

The dotted and dashed line is the closest to the origin which intersects feasible space, and represents a cost of $4.37. It intersects feasible space at the point (61, 39), which says that the most economical mix for the foundry to use is 61 lb of input *B* and 39 lb of input *A*. This is the graphical solution to the simplified L. P. problem.

If another input were to be considered along with inputs *A* and *B*, we would need a third axis to represent it. The problem would then be in three dimensions, and we might still be able to visualize it geometrically. If *n* inputs were to be considered however, the problem would be one in *n* dimensional space, and analytic techniques which correspond to the geometrical representation would have to be used to extract a solution. Virtually all real problems involve the evaluation of many variables, and such analytic methods must be employed.

THE SIMPLEX SOLUTION

For the interested reader, we will now solve the simplified problem shown above by the simplex method* an iterative algebraic procedure developed by George Dantzig.†

The algebraic statement of the problem [Equations (1) to (4)] is again listed:

$$0.02X_A + 0.07X_B + S_1 = 0.05(100)$$
$$0.05X_A + 0.06X_B + S_2 = 0.07(100)$$
$$0.08X_A + 0.04X_B + S_3 = 0.07(100)$$
$$X_A + X_B + S_4 = 100$$

The meaning of S_1, S_2 and S_3 we are familiar with; they are slack variables designed to allow the final contents of elements 1, 2 and 3 to be less than the maximum limit imposed on these final contents. S_4 is what is called an artificial slack variable. Expression (4) is not an inequation, so although for computational purposes it is desirable to include with it a slack variable, this slack will not be allowed to appear in the final solution (by associating with it a high cost, M).

The equations as listed are put in matrix form, as shown in Table 6. The coefficients of the slacks are 1, and the initial solution is that indicated by the symbols in the first column. This first solution indicates that slack is used to the exclusion of products. This is

TABLE 6

Initial Solution	INPUTS S_1	S_2	S_3	S_4	X_A	X_B	Amount in Solution
S_1	1				0.02	0.07	5
S_2		1			0.05	0.06	7
S_3			1		0.08	0.04	7
S_4				1	1	1	100

*See Bowman and Fetter, *Analysis for Production Management*, Richard D. Irwin, Inc. (1957).

†G. B. Dantzig, "Maximization of a Linear Function of Variables Subject to Linear Inequalities," appearing in Ref. 5.

TABLE 7

		INPUTS							
	Profit:	0	0	0	−M	−5	−4		
Profit	Initial Solution	S_1	S_2	S_3	S_4	X_A	X_B	Amount in Solution	Determination of Smallest restriction
0	S_1	1				0.02	0.07	5	/0.07 = 71.4
0	S_2		1			0.05	0.06	7	/0.06 = 116.6
0	S_3			1		0.08	0.04	7	/0.04 = 175
−M	S_4				1	1	1	100	/1 = 100
		0	0	0	−M	−5	−4		
						−0	−0		
						−0	−0		
Profit						−0	−0		
Function:						−(−M)	−(−M)		
						+M	+M		

TABLE 8

	Profit:	0	0	0	−M	−5	−4		
Profit	Solution	S_1	S_2	S_3	S_4	X_A	X_B	Amount in Solution	Determination of Smallest restriction
−4	X_B	14.3				0.286	1	71.4	/0.286 = 250
0	S_2	−0.86	1			0.0328		2.72	/0.0328 = 83
0	S_3	−0.57		1		0.069		4.14	/0.069 = 60
−M	S_4	−14.3			1	0.714		28.6	/0.714 = 40
		0	0	0	−M	−5	−4		
Profit		−14.3(−4)				−0.286(−4)			
Function:		−(−14.3)(−M)				−0.714(−M)			
		−M				+M	−4		

TABLE 9

	Profit:	0	0	0	−M	−5	−4	
Profit	Solution	S_1	S_2	S_3	S_4	X_A	X_B	Amount in Solution
−4	X_B	−20	0	0	1.4	0	1	59.95
0	S_2	0.2	1	0	−0.4	0	0	2.59
0	S_3	0.43	0	1	−0.046	0	0	3.86
−5	X_A	−2	0	0	−0.097	1	0	40
Profit Function:		−90	0	0	−M	0	0	

equivalent in the geometrical representation, to starting at the origin.

The proper input to be brought in must now be determined. Below each column in Table 6 is shown the profit (costs are negative profits) to be realized for each unit of input brought into solution. The coefficients in Table 6 represent rates of substitution between the various inputs. So, for example, the profit for each unit of X_A brought in is its profit per unit, −5, less the profits lost when substituting X_A for each of the inputs in the present solution, the slacks.

This is $-5-[-0.02\times0-0.05\times0-0.08\times0-(-M)]$, equals approximately $+M$ (since M is a large cost and outweighs the other factors). X_B has a similar net profit per unit of $+M$, so it is immaterial at this stage whether X_A or X_B is introduced into solution. X_B was chosen. Because we are dealing with linear relationships (there is no falling off of utility when introducing X_B), we bring in as much X_B as is technically feasible. If we divide each capacity restriction by the substitution rates of the product going in, we get limits to the number of units of X_B which can go into solution.

The smallest capacity restriction is the largest number of units which can be brought in, and we substitute X_B for that product in solution which offers the restriction. In the right hand column of Table 7 we see that 71.4 is the smallest capacity restriction. What we have just done is equivalent in the graphical solution to moving out along the abcissa (B axis) from the origin until the first capacity restriction is reached.

The other products no longer have their original number of units in solution. We derive the new solution by multiplying the number in the present solution by the proportion of the capacity remaining:

$$S_2 = 7 \times \frac{116.6 - 71.4}{116.6} = 2.72$$

$$S_3 = 7 \times \frac{175 - 71.4}{175} = 4.14$$

$$S_4 = 100 \times \frac{100 - 71.4}{100} = 28.6$$

These new values are shown in the solution column of Table 8. In Table 8, the new substitution rates (coefficients in the Table) must be calculated, because we have new row headings (the inputs in the new solution), and the products which can be brought into solution must be expressed in terms of this new set of variables. The procedure is as follows:

1) Express the rates of substitution from Table 7 for the product brought into the new solution:

$$X_B = 0.07\,S_1 + 0.06\,S_2 + 0.04\,S_3 + S_4$$

2) Solve for the product being replaced (S_1).

$$S_1 = 14.3X_B - 0.86\,S_2 - 0.57\,S_3 - 14.3\,S_4$$

These are the new rates of substitution for S_1.

3) For the new substitution rates of other products, substitute the calculated values of S_1 in the expressions describing the old substitution rates.

$$\begin{aligned} X_A &= 0.02\,S_1 + 0.05\,S_2 + 0.08\,S_3 + S_4 \\ &= 0.02\,(14.3X_B - 0.86\,S_2 - 0.57\,S_3 - 14.3\,S_4) \\ &\quad + 0.05\,S_2 + 0.08\,S_3 + S_4 \\ &= 0.286X_B + 0.0328\,S_2 + 0.069\,S_3 + 0.714\,S_4 \end{aligned}$$

These new rates are inserted in Table 8. The entire procedure is now repeated: Evaluating the most profitable input to bring in, determining the limiting product which comes out of solution and computation of new solution and substitution rates. When the profit functions for each input are computed to be negative, the problem is solved. The solution is found in Table 9 which specifies that 59.95 units of X_B, and 40 units of X_A are to be employed. This solution corresponds to the one obtained graphically, the slight discrepancy being due to round-off errors.

Instructors Seminar Outlines Methods for Improving School Foundry Programs

■ How to obtain maximum benefits from secondary-school level foundry and patternmaking programs will be outlined June 18-20 at the AFS 4th Annual Foundry Instructors Seminar.

The Seminar will be held at the University of Illinois, Urbana, Ill., sponsored by the Foundry Instructors Seminar Committee of the AFS Education Division and presented in cooperation with the University of Illinois Division of University Extension.

Co-chairmen for the Seminar will be Prof. Roy W. Schroeder, Department of Mechanical Engineering, University of Illinois, Navy Pier, Chicago, and Vice-Chairman of the AFS Education Division; and R. E. Betterley, AFS Education Director.

The tentative program highlights are as follows:

THURSDAY, JUNE 18

9:00 am—*Registration*, Illini Union Ballroom, second floor.
10:00 am—*Welcome and Orientation*, R. E. Betterley, AFS Education Director.
10:15 am—*Welcome*, Dr. Gordon Ray, Vice-President, University of Illinois.
10:20 am—*Atomic Age Foundryman*, K. J. Trigger, Professor, Mechanical Engineering, University of Illinois.
10:40 am—*AFS Activities*, A. B. Sinnett, AFS Secretary.
11:00 am—*Sand in the School Foundry*, V. M. Rowell, Harry W. Dietert Co., Detroit.
12:00 Noon—*Lunch*
1:00 pm—*School-Plant Liaison*, R. A. Oster, Director, Beloit Vocational & Adult School, Beloit, Wis.
1:45 pm—*Ventilation for the School Foundry*, H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control Program.
2:30 pm—*Wood Patternmaking in the School*, F. C. Cech, Head, Patternmaking department, Max S. Hayes Trade School, Cleveland.
3:15 pm—*Administrative Problems in Setting Up School Foundries*, E. M. Claude, Chief, Trade Industrial Education, Board of Vocational Education, Springfield, Ill.
5:15 pm—*Dinner and Field Trip at Danville, Ill.*, Inspection of Central Foundry Div., GMC, Danville, Ill.

FRIDAY, JUNE 19

9:00 am—*Making a Crucible Furnace for School Use*, Dr. C. Rischer, Assistant Professor, Industrial Education, Western Michigan University, Kalamazoo, Mich.
10:00 am—*Demonstration Workshops Orientation*, Prof. J. L. Leach, Associate Professor, Mechanical Engineering, University of Illinois.
10:20 am—*Demonstration Workshops*, including melting, molding, coremaking, CO_2 and shell processes, sand testing and wood patternmaking.
12:00 Noon—*Lunch*
1:00 pm—*Demonstration Workshops.*
3:00 pm—*Pouring Instructions*, Prof. J. L. Leach.
3:15 pm—*Pouring the Heat.*
7:00 pm—*Banquet*, Lincoln Hotel, Urbana, Ill. Speaker, Wm. W. Maloney, AFS General Manager.

SATURDAY, JUNE 20

8:30 am—*Instructional Aids and Materials*, T. H. Boardman, Supervisor, Visual Aids Service, Division of University Extension, University of Illinois.
10:15 am—*Planning and Equipping A School Foundry.*
Selling the Program—John Strange, Foundry Instructor, Sterling Township High School, Sterling, Ill.
Shop Layout & Equipment—Joseph Madru, Foundry Instructor, Sherman High School, Chillicothe, Ohio.
Course of Instruction—Andrew Bottoni. Foundry Instructor, Milwaukee Vocational & Adult School, Milwaukee.
Teaching the Program—Robert Speerbrecher, circuit foundry instructor, State Department of Vocational & Adult Education, Madison, Wis.
11:30 am—*Shakeout.*
12:00 Noon—*Getaway Luncheon.*
1:00 pm—*Evaluation Meeting.*

1959 Regional Foundry Conferences

June 25-27 Penn State Foundry Conference, Pennsylvania State University, University Park, Pa.
Sept. 24-25 Missouri Valley Regional Foundry Conference, University of Missouri, School of Mines & Metallurgy, Rolla, Mo.
Oct. 1-2 Niagara Frontier Regional Foundry Conference, Syracuse, N.Y.
Oct. 2-3 Northwest Regional Foundry Conference, Benjamin Franklin Hotel, Seattle, Wash.
Oct. 8-9 Michigan Regional Foundry Conference, Pantlind Hotel, Grand Rapids, Mich.
Oct. 16-17 New England Regional Foundry Conference, Massachusetts Institute of Technology, Cambridge, Mass.
Oct. 22-23 Ohio Regional Foundry Conference, Deshler-Hilton Hotel, Columbus, Ohio.
Oct. 29-30 Purdue Cast Metals Conference, Purdue University, Lafayette, Ind.

AFS 1896

news and views

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TEXAS Regional Conference

CHARLES R. McGRAIL
GENERAL CHAIRMAN

■ Between the opening words of welcome by the Honorable J. E. Kuykendall, Mayor of San Antonio, and the closing words of appreciation by AFS Texas Chapter Chairman Harold H. Judson, the Texas Regional Conference occupied two big Texas days with a king-sized program of modern technology adapted to southwestern foundry operations.

A. DORFMUELLER, JR.
Archer-Daniels-Midland Co.
Cleveland

"Which Core Process"

Shell Cores: Best suited for high and medium production where complex design or close tolerances are a problem. CO_2 Process: Best for medium-sized, low production cores used in non-ferrous as well as steel foundries. Air-Setting Process: Best for cores weighing over 1000 lb or taking over an hour to make.

O. J. MYERS
Reichhold Chemicals, Inc.
White Plains, N.Y.

"Self-Hardening Binders"

Use self hardening binders for . . . less gas . . . less rodding . . . less baking . . . less labor . . . excellent flowability . . . good collapsibility . . . high surface hardness. But remember that . . . core box is tied up . . . control is difficult . . . you need dry sand . . . mix is temperature dependent . . . binder has high cost.

H. VON WOLFF
Shalco Corp.
Palo Alto, Calif.

"Shell Cores"

New trend to use of cheaper, more collapsible urea binders for shell cores. Surface defects on steel cast in shell molds now eliminated by new sand additive. Blowing shell molds for stacking 16 high. Blowing shell liners for setting in permanent aluminum back-up molds for light dimensional stability.

R. A. CLARK
Union Carbide Metals Co.
Cleveland

"Developments on Cupola Design and Operation"

Acid cupola is versatile and can be improved with hot blast, dehumidification and improved charging. Non-uniform distribution of charged materials produces erratic results at spout. Adding carbon in forehearth permits use of cheaper raw materials.

J. BRIDGES
Cameron Iron Works
Houston, Texas

"Dry Air vs. Oxygen for Carbon Reduction"

Air must be dried before blowing into molten steel. An inexpensive drier can be built. Melt should be blown at as high a starting temperature as feasible. Adding oxygen to the air speeds carbon removal while nitrogen in air keeps bath temperature down.

D. E. CUTLER
J. S. McCormick Co.
Pittsburgh, Pa.

"Carbon Mold Materials"

Carbon sand resists metal penetration because it is not wet by molten metal, has low expansion and is stable to heat shock. Carbon sand or flour can be mixed with sand or used separate for molds, mold facings and cores.

D. L. LAVELLE
American Smelting & Refining Co.
South Plainfield, N.J.

"Aluminum Casting Quality Control"

Dross and oxide come from mixing air into molten aluminum. Flux inclusions are stirred into melt and entrapped before they can escape. Trapped air is carried into casting by turbulence in sprue. Hydrogen gas is dissolved from moisture and increased by overheating.

G. GOTTSCHALK
Thiem Products, Inc.
Milwaukee

"Modern Concepts of Refractory Castings"

Mold coatings can be water-base (requiring drying) or solvent-base, which can be ignited for self drying. Washes using olivine or zircon have a desirable chill effect.

P. B. CROOM
Houston Pattern Works
Houston, Texas

"Pattern Engineering"

Properly engineered pattern requires close cooperation of customer, patternmaker and foundryman. Pattern specifications must be detailed and specific. Patternmakers need clarified nomenclature to aid in specifying quality.

■ Conference General Chairman Charles R. McGrail said, "This has been our most successful regional conference. Over 225 foundrymen were on hand to hear 18 top-notch metalcasting experts cover the full gamut of foundry operations. And beautiful spring weather permitted the 52 ladies on hand to enjoy the outdoor program planned for them."

■ One of several social highlights was a "Texarific" barbecue, staged at an indoor corral with all the atmosphere of a dude-ranch setting. An hour-long entertainment with Mexican flavor climaxed the evening. According to K. E. Kielty, Conference publicity chairman, "Over 250 foundry mavericks were on hand for the occasion."

■ The Conference closing banquet was a sell-out. Each of the 14 past chairmen of the Texas Chapter was presented a handsome cast bronze plaque at an after-dinner ceremony. The Chapter's first chairman and only two-termer, F. M. Wittlinger, was present to receive the first recognition. Banquet speaker Dr. Harold Vagtborg, Southwest Research Institute, San Antonio, left a vivid impression of the importance of "Water" to the future of Texas.

C. F. LEWIS
Cook Heat Treating Co. of Texas
Houston, Texas

"Heat Treatment of Steel Castings"

If foundrymen will become thoroughly familiar with the iron-carbon diagram and the TTT curves, they will understand the effects of temperature and cooling rate on metallurgical reactions in steels.

L. J. VENNE
Union Carbide Metals Co.
Cleveland

"Steel Melting for Castings"

Castings can be no better than the quality of metal put into the mold. This quality is largely determined by the many variables inherent to the melting operations.

T. E. KRAMER
American Alloys Corp.
Kansas City, Mo.

"Aluminum Melting and Pouring Practice"

If you see popcorn dross on top of metal coming up in riser, your gating system is letting dirt get into casting. To pour clean non-turbulent metal, use small sprue tapered down to 1/4-1/2-in. diameter, place sump under sprue, put steel wool in sump, and have choke gate leading off from sump.

E. MOONEY
Benj. Harris & Co.
Chicago Heights, Ill.

"Common Sense in the Brass Foundry"

Common sense teaches foundrymen to profit from mistakes of others and apply this knowledge to daily problems. To make quality brass castings . . . melt fast . . . don't overheat . . . don't agitate melt . . . skim properly . . . control deoxidation . . . keep sprue choked.

T. E. BARLOW
International Minerals & Chemical Corp.,
Skokie, Ill.

"Cupola Refractories"

Cupola refractory consumption comes from heat disintegration, mechanical spalling and chemical attack from slag. Latter source is major problem. Fluid slags dissolve refractory lining while viscous slags provide a protective coating for the cupola lining.

V. H. PATTERSON
Vanadium Corp. of America,
Chicago

"Modern Gray Iron Metallurgy"

Grain structure of cast iron starts with primary austenite crystallization followed by solidification of the low-melting eutectic and graphite formation. Late inoculation of the melt produces uniform graphite size and distribution with an accompanying improvement in mechanical properties.

D. DAVIS
Oklahoma Steel Castings Co.
Tulsa, Okla.

"C Process"

Exceptionally fine surface is obtained on carbon steel with over 0.45 per cent carbon and on all grades of stainless steel . . . Too low a pattern temperature promotes peelback . . . Too high, causes areas of shell to drop off plate . . . Spent shell molding sand can be reclaimed by igniting in an incinerator, using the resin coating as the fuel . . . Surface finish is improved by adding 3-4 per cent of $CaCO_3$

R. COCHRAN
R. Lavin & Sons, Inc.
Chicago

"Brass and Bronze Casting Quality Control"

High melt quality requires . . . clean dry material . . . moisture-free furnace and ladle linings . . . short melting cycle . . . oxidizing melting atmosphere . . . minimum temperatures. Ideal gating permits . . . non-turbulent mold filling . . . no aspiration of air or gas . . . dross and slag entrapment . . . minimum erosion of mold and core surfaces.

D. MATTER
Ohio Ferro-Alloys Corp.
Canton, Ohio

"Gating and Risering"

Many foundries use the volume increase associated with graphite formation to feed shrinkage. This growth can be used to produce x-ray sound castings as large as 5 tons without any risers. Risers placed between runner and ingate are termed "hot risers." They are 50 per cent more efficient than "cold risers."

West Coast

Enjoying a chuckle are AFS President **L. H. Durdin**, AFS General Manager **Wm. W. Maloney** and AFS Directors **Jake Dee** and **John Russo.**

California Conference officials: Southern California Chapter Chairman **Otto H. Rosentreter**; Conference Technical Section Chairman **Paul Bergmann**; Conference Chairman **E. G. Gaskell.**

Foundrymen Discuss Today's . . .

■ Present and future developments in foundry processes and metals, patternmaking and cleaning room practices were evaluated at the California Regional Foundry Conference held March 13-14 at Pasadena, Calif.

The conference, attended by 355 west coast foundrymen, was sponsored by the Southern and Northern California Chapters with the Southern California Chapter acting as host. E. G. Gaskell, Ace Foundry Ltd., Huntington Park, Calif., served as conference general chairman. Paul Bergmann, Westlectric Casting, Inc., Los Angeles, was technical section chairman.

Specific division meetings as well as general sessions were conducted during the two-day conference held at the Huntington-Sheraton Hotel.

In addition to the technical talks, foundrymen heard Maj. Gen. Joseph D. Caldara, director of flight safety research, office of the Inspector General, Norton Air Force Base, San Bernardino, Calif., stress the importance of furnishing specification components for aircraft because of the ever-increasing stresses caused higher speeds of modern jet aircraft.

AFS President L. H. Durdin emphasized the vital need of a basic research program in the foundry industry for developing better castings, sales and marketing procedures. Northern California Chapter Chairman Gordon L. Martin invited foundrymen to attend the AFS National Convention to be held in 1961 in San Francisco.

Prior to the opening of the technical sessions, a welcoming address was made by Southern California Chapter President O. H. Rosentreter and Conference Chairman E. G. Gaskell.

Ferrous Sessions

WHAT IS THE FUTURE of castings in this moving world? In answering this, John M. Anspach, Meehanite Metal Corp., New Rochelle, N. Y., reviewed the recent history of the foundry industry noting that for the past 30 years foundries had developed quality standards to meet the demands of the two largest purchasing groups—the automotive and railroad industries.

"New eras, specifically electronics and the jet air age, are approaching. Many feel that they are already here," warned Anspach. "To get their share of this potentially lucrative business foundries must forget the present acceptance standards and adopt stricter techniques."

Said Anspach, "If the challenge of producing castings to these more exacting standards proves disconcerting to you as a foundryman, consider yourself normal. Perhaps you have sufficient commercial business on the books to keep your facilities operating at a high rate well into the foreseeable future. Or maybe you simply have no inclination to even attempt the manufacture of castings of this nature; but remember, to live is to continue to learn, and eventually most castings will be made to a new series of standards based on the requirements of these young but rapidly developing industries."

THE FOUNDRY INDUSTRY and ductile iron producers in particular, were also challenged by Frank F. Brendler, Stanley Foundries, Inc., Huntington Park, Calif., who discussed the present and future of ductile castings.

Speaker **Anthony Polizzotto** (left) and **Henry Howell,** session chairman.

"Since we are generally competing with the forging and fabrication field, we must devise methods to produce better and more economical parts, stated Brendler.

Utilization of the characteristics of the material to its best advantage include:

- More unique pattern equipment to increase production and reduce costs.
- More efficient methods of gating and risering to improve casting yield.
- More complex coring, such as obtained by the use of shell cores, to eliminate excessive machining.
- More reductions in section size to eliminate weight and size.

Other observations by Brendler applying to all casting producers were:

- Send out only qualified salesmen and provide them with sufficient tools.
- Be certain that salesmen make a thorough study of the parts to be bid on so that incorrect applications are avoided.
- Produce quality castings, shipped on schedule at a competitive price.

CONTINUOUS METAL FLOW and low maintenance charges are highly important considerations in the automotive industries. A high volume of metal is a must to guarantee the continuous flow of parts on highly automized lines observed H. W. Schwengel, Modern Equipment Co., Port Washington, Wis., in discussing new developments in equipment for melting and charging.

The problem is further complicated since automated operations are largely concentrated in congested metropolitan areas which require strict control over cupola emission.

Schwengel described new equipment which includes a sealed cupola, mechanical charger which is designed to best service the type of cupola involved, a new approach to recuperative hot blast, emission clean-

Speaker **Hubert Chappie** (center) flanked by session chairman **E. G. Emmett** and co-chairman **Paul Crow.**

Seated at head table are: National Director **Jake Dee,** Northern California Chapter Chairman **G. L. Martin,** Regional Vice-President **J. R. Russo,** Conference Chairman **E. G. Gaskell** and Session Chairman **C. F. Weisgerber.**

.....Tomorrow's.....Problems

ing as desired and a specially designed, externally water-cooled cupola.

Another ferrous speaker, Hubert Chappie, National Supply Co., Torrance, Calif., discussed *Sand and Related Facts.*

Molding Symposium

Three types of molding were discussed by California foundrymen at the opening session.

SHELL MOLDING HAS BEEN the most important new process in steel foundries, stated Walter Dunn, Pacific Alloy Engineering Corp., El Cajon, Calif. Advantages of the process include excellent mold collapsibility, improved finish, good tolerances and lower cost.

Shell molding and other processes have contributed largely to the ability of steel foundries to produce parts beyond their capabilities of a few short years ago. One of the big steps forward has been the increase in casting size while maintaining relatively thin wall sections.

Ceramic molding has produced castings up to 300 lb but most castings are in the 30-lb range, observed Leonard Dean, Brea Alloys & Mfg. Co., Brea, Calif. This process, which has seen a steady increase in popularity, uses standard patterns but calls for alterations in gating and risering. Gating, risering and pouring also differ from conventional practice.

Sodium silicate molding was outlined by Frank Brewster, Brumley Donaldson Co., Huntington Park, Calif.

Induction Melting

A second conference symposium discussed induction melting of steel, iron and non-ferrous metals.

INDUCTION MELTING OF IRON, drawn from Dayton Foundry's two-year experience with 60-cycle, cored induction furnaces was outlined by M. B. Hartman. Advantages of this furnace include availability of operating power, practically noiseless operation, elimination of need for air pollution control equipment and close chemical control. Hartman cited chemical control as the most important advantage. Due to construction and method of heat addition, uniform temperatures are maintained, hot spots are eliminated and during melting the furnace can be sealed up completely; also the furnace does not require a skilled operator to obtain close control.

Hartman emphasized that the furnace is available only in capacities from 150 to 1500 lb hourly. Other limitations call for a spare furnace shell, the need for keeping molten metal in the furnace on a 24-hour, 7-day basis.

Melting of steel was discussed by J. W. Mitchell, Utility Steel Foundry, Vernon, Calif., and non-ferrous melting was explained by A. W. Nash, A. W. Nash Co., Los Angeles.

Cleaning Room Problems

BLAST CLEANING EQUIPMENT appears to be operated at less than 50 per cent efficiency even in supposedly good operations, observed G. O. Pfaff, Wheelabrator Corp., Mishawaka, Ind. Pfaff outlined a control program for isolating causes of inefficiency which included operating controls designed to check the efficiency of the machine; regular additions to the abrasive mix; screen analysis of separator discharge; and a regular inspection of the machine itself.

Once operating controls have been established, cost controls should be instituted which should be expressed in cost per wheel rather than in cost per ton cleaned.

Maj. Gen. **Joseph D. Caldara,** banquet speaker addressing California Regional.

Equipment Sessions

PRESSURE MOLDING WAS defined by W. L. Adams, Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill., as a controlled green sand molding process in which mold shape, sand flowability and molding pressure are combined to produce molds hard and dense enough to reproduce pattern dimension and finish with extreme accuracy and uniformity.

Advantages of the system include:

- Elimination of "human error" scrap.
- Reduction of casting and sprue weight.
- Closer dimensional control and accuracy.
- Elimination of tucking and peening time.
- Lower overall maintenance.
- Unusual speed potentials.

Pneumatic sand reclamation and conveying was described by R. L. McIlvaine, National Engineering Co., Chicago.

Non-ferrous sessions were conducted during both days of the regional. Speakers and their topics included: Norman Barnett, M. Greenberg's Sons's, San Francisco; *General Non-Ferrous Foundry Practice;* George W. Stewart, East Bay Brass Foundry, Richmond, Calif., *Some Aspects of Pouring and Molding Aluminum;* William Bailey, Douglas Aircraft Co., Los Angeles, *Today's Problem in Magnesium Castings;* Anthony Polizzotto, A & M Castings, Inc., South Gate, Calif., *The Present and Future of Aluminum Castings.*

Two patternmaking meetings were conducted. Paul C. Ricks, AiResearch Mfg. Co., Los Angeles, spoke on *Tomorrow's Castings – A Challenge to Pattern Design* and Allen Cooper, Furane Plastics, Inc., Los Angeles, addressed foundrymen on *Epoxy Resins–A Practical Tool for the Patternmaker.*

■ Conference details provided by California Regional Publicity Chairman Earl Appleman and Conference Photographer K. F. Sheckler, both of Calmo Engineering Co., Los Angeles.

T&RI Presents Course in Canada

■ For the second time in slightly over a year, Canada's Ontario Chapter is co-sponsoring an AFS Training & Research Institute course. *Melting of Copper-Base Alloys* will be presented May 4-5 at the Royal Connaught Hotel, Hamilton, Ont.

This follows by two weeks *Gating & Risering of Casting* courses given in California under co-sponsorship with the Southern California and Northern California Chapters.

During the four-month period, May - August, six courses will be held by T&RI. Two will be held for the first time. These are *Metallurgy of Gray Iron* and *Core Sand Practice*. Both have been scheduled in response to requests by T&RI students.

The *Melting of Copper-Base Alloys* includes major sections on classification and definition of alloys; melting equipment covering both electric furnaces and fuel-fired furnaces; control of melt quality; test procedures for quality control.

Cupola Melting of Iron, scheduled for May 11-15 in Chicago has been attended by more T&RI students than any other subject—proof of the continuing interest in this basic operation.

Metallurgy of Gray Iron will be given for the first time May 25-27 in Chicago. The outline includes the following topics.

What is Gray Iron?—Definition; iron-carbon equilibrium systems; metastable iron-iron carbide system.

Solidification of an Fe-C-Si Alloy—Graphitization during solidification; graphitization by carbon precipitation; graphitization during the eutectoid transformation; mechanics and typical structures formed.

Effect of Chemical Composition—Importance of elements; carbide stabilizing; graphitizing; combinations of elements; mechanical properties; effect of elements on carbon, silicon, manganese, phosphorous, chromium, copper, molybdenum, nickel, vanadium, titanium, boron and telurium.

Inoculation—Alloys usually used; method and time of addition; quantity of alloy used; effect on behavior of iron and its mechanical properties; upgrading by injection into molten iron.

Relation of Carbon Equivalent to Mechanical Properties of Gray Iron.

Improvement of Gray Iron Through Use of Alloys.

Section Sensitivity of Gray Iron.

Effect of Superheating During Melting—Induces supercooling; tends to dissolve carbon nuclei; tends to obliterate heredity; increases chilling propensity.

Microstructure of Gray Iron—Base structure, effect of heat treatment.

1959 T&RI Courses

May-August

Subject and Description — *Dates*

Melting of Copper-Base Alloys .....**May 4-5**
Course of instruction for melters supervisors, metallurgists and foremen. Nomenclature, alloy classification, melting fundamentals, equipment, controls, testing and raw materials. Basic control variables are considered in light of optimum results. Course M2A, $45, Hamilton, Ont.

Cupola Melting of Iron .....**May 11-15**
Instructional course for cupola operators, supervisors, metallurgists and foremen. Basic principles for efficient cupola operation are studied with emphasis on cost reduction. Raw materials, cupola design, combustion control, metallurgy of cast iron, maintenance and new developments. Course M3A, $90, Chicago.

Metallurgy of Gray Iron .....**May 25-27**
Intensive instruction on the basic metallurgy of gray iron. Metal compositions, alloys, physical and mechanical properties. Photo-micrographic examples are shown with the interpretation of microstructures. Controlling mechanical properties. For melters, metallurgists, engineers, researchers, supervisors and management. Course MET1A, $60, Chicago.

Metallography of Non-Ferrous Metals .....**July 13-15**
Demonstration and work shop course for melters, supervisors, foremen, foundry engineers, researchers, laboratory technicians, metallurgists and design engineers. Basic metallurgy, terminology, phase diagrams, micro and macro analyses, mechanical properties based on metallographic interpretation and heat treatment are studied. One day on demonstrations and workshop activities in the laboratory. Metal specimens are prepared and studied. Course MTY2A, $80, Chicago.

Core Sand Practice .....**Aug. 10-14**
Instruction covering all phases of materials, mixing and application. The advantages and disadvantages of new materials and methods are studied. Casting losses attributed to cores are analyzed for solutions. Designed for foremen, supervisors, technicians, engineers and management. Course SC1A, $90, Chicago.

Gating & Risering of Castings .....**Aug. 24-26**
Instruction course covering theory and practice on the various problems relating to gating and risering. Metal flow, solidification phenomena, heat transfer, shrinkage, hot tears, ferro-static pressure, gate and riser design, mold wall movement and surface tension are some of the many facets covered. Intended for foremen, technicians, foundry engineers, industrial engineers and production and quality control personnel. Course GRIB, $60, Chicago.

Payment of Tuition Fees should accompany enrollment application. Make all reservations ONLY with Director, AFS Training & Research Institute, Golf & Wolf Roads, Des Plaines, Ill. Tel. VAnderbilt 4-0181.

Penn State Regional Conference Will Concentrate on Five Major Subjects

■ Technical sessions on gray iron, malleable iron, non-ferrous alloys and sand will be held at the Penn State Foundry Conference to be held June 25-27 at Pennsylvania State University, University Park, Pa.

Participants have been announced for the sand, non-ferrous and malleable sessions.

Sand—Coordinator, Stewart Wick, New Jersey Silica Sand Co. Participants: Henry W. Meyer, General Steel Castings Corp., Granite City, Ill.; Larson Wyle, Pangborn Corp., Hagerstown, Md.; Thomas C. Jester, Darling Valve & Mfg. Co., Williamsport, Pa.; John Fuqua and Joseph Lessman, Copper Alloy Corp., Hillside, N.J.; Paul W. Green, General Electric Foundry Division, Erie, Pa.

Non-Ferrous—Coordinator, George J. Miklos, Westinghouse Electric Co. Participants: A. R. Barbour, Roessing Bronze Co., Pittsburgh, Pa.; R. Cochran, R. Lavin & Sons, Chicago; C. E. Coulter, Archer-Daniels-Midland Co., Cleveland; E. Belkin, Westinghouse Electric Co., East Pittsburgh, Pa.; J. H. Dunn, Aluminum Co. of America, Cleveland.

Malleable Iron—Coordinator, David Tamor, American Chain & Cable Co. Participants: J. B. LaPota, National Cylinder Gas Co., Div. Chemtron Corp., Chicago; Dr. Lauriston C. Marshall, Link-Belt Co., Indianapolis; Carl F. Joseph, Central Foundry Division, GMC ,Saginaw, Mich.; Richard E. Rosien, Eastern Malleable Iron Co., Wilmington, Dela.

The conference, similar to the first held in 1957, will open with technical sessions on Thursday afternon, June 25, and a social hour that evening. Technical sessions will be held again Friday morning with general meetings in the afternoon and a banquet in the evening.

Saturday's schedule consists of general technical sessions followed by adjournment.

Chapters Can Aid Handbook Group

■ Chapters have been requested to assist the Controlled Casting Quality Committee of the Sand Division in providing illustrative material for the CASTINGS DEFECTS HANDBOOK.

The committee is seeking castings or pictures showing defects and their method of correction. Gates and risers should be shown in the photograph or sketches. The committee is interested in all metals made by the various methods or casting processes.

Information desired:

- Name of defect.
- Percentage of defect when it occurred.
- Photograph or sketch of complete casting including gates and risers. If a photograph is submitted, include a letter to give idea of relative size.
- Metal sections and weight of castings.
- Metal type and analysis.
- Molding medium.
- Molding method and equipment.
- Pattern equipment and rigging.
- Sand or core composition and properties.
- Molding characteristics.
- Melting and pouring data.
- Ladle practice.
- Apparent cause.
- Describe cure used.
- Comments.

Sand Committee to Study Procedures

■ Standard procedures for divisional operations are being studied by a six-man committee of the Sand Division. When approved by the division, the procedures will be submitted to other divisions for consideration as a possible uniform policy.

Members of the committee appointed at the January meeting of the division's Executive Committee are: Chairman L. J. Pedicini, O. J. Myers, E. C. Zirzow, V. M. Rowell, C. A. Sanders and T. W. Seaton.

Committee reports included:

Materials Used in Malleable Foundries—Developing a questionnaire regarding porosity and also conducting literature survey.

Core Bakeability—Core boxes being constructed for use in determining if a suitable bakeability test can be developed.

Molding Methods & Materials—Basic work has been completed on book MOLDING METHODS & MATERIALS.

Physical Properties of Steel Foundry Sands at Elevated Temperatures—Conducting tests to establish the source of dirt and other foreign materials in steel castings.

Basic Concepts Committee—Currently engaged in studies on the packing of unbonded sands.

Parkes Becomes European Technical Writer

■ A. R. Parkes, assistant editor of the *Foundry Trade Journal*, London, England, has been designated the official AFS European technical correspondent. Parkes is well qualified to keep AFS members in this country informed of the latest overseas technical developments.

Besides a busy journalism career, he is active in the Institute of British Foundrymen as a member of the General Council, deputy branch delegate to the Technical Council and a member of the Literary and Awards Committee. Before joining the staff of the *Journal* in 1947, Parkes had wide experiences as metallurgist for the Suffolk Iron Foundry, Ltd., James & Co. Ltd., Gabriel & Co. Ltd., and John Harper & Co. in England, plus a period at the Kulti foundries of the Indian Iron & Steel Co.

He will provide the Society and MODERN CASTINGS with highlights of important foundry industry meetings in Britain and the continent. With Parkes "on location" in the European theatre of metalcasting activity it can be expected that the information pipeline to the States will be considerably improved with broadened coverage of new technical developments, plant operations and activities of foreign foundrymen.

Why More Members in AFS

■ The sole job of AFS is to develop and distribute data on foundry production, processes and methods. Membership is the most practical method of distribution.

national news

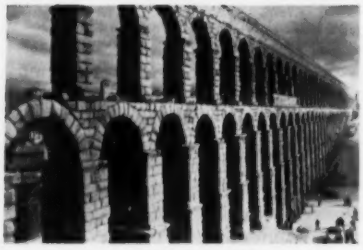
Technical Sessions, Tours Scheduled for International

■ Technical sessions are scheduled for three days of the International Foundry Congress with one day devoted to International committee meetings. The 26th International Foundry Congresses, to be held Oct. 4-10 in Madrid, Spain, opens officially at 11:00 am, Tuesday, Oct. 6, followed by sightseeing tours in the afternoon, a reception of delegates in the evening and a social program.

Opening sessions for the remainder of the International run from 9:00 am to 1:00 pm with the program resuming at 4:00 pm.

Wednesday will be devoted to technical sessions in the morning and an afternoon visit to the Spanish Higher Council for Scientific Research and an evening reception.

Meetings of the International committee groups will open Thursday's activities with sessions of the International Committee of Foundry Technical Associations scheduled for the afternoon. A banquet for official delegates will be held at 10:00 pm.



View of **aqueduct** near Sequoia

Technical sessions will resume Friday with a tour planned for the afternoon and a closing banquet at 10:00 pm.

The International will be concluded Saturday with technical meetings in the morning and a formal closing at 4:00 pm.

Post-Congress tours will follow the International including a special tour for Americans sponsored by AFS.

France Schedules Two-Day Foundry Congress in June

■ France's foundry technical association, Association Technique de Fonderie de France, will hold its 32d Congress in Paris, June 1-2.

Technical meetings will be held June 1 with 14 original papers scheduled for presentation. The second day of the Congress will be devoted to plant visitations. No provision has been made for a ladies day program or for a post-Congress tour.

Gray Iron Division Elects R. A. Clark, H. Henderson

■ Ralph A. Clark, Electric Metallurgical Co., Div. Union Carbide Corp., Cleveland, has been elected as Chairman of the Gray Iron Division. Harvey Henderson, Lynchburg Foundry Co., Lynchburg, Va., has been elected Vice-Chairman of the division. Both Clark and Henderson will be installed as division officers at the Technical Council meeting in May.

Reviewing course material at Birmingham are, sitting: **Earl Moran,** Arwood Precision Casting Corp., Groton, Conn.; **William Storey,** Arwood Precision Casting Corp., Tilton, N. H.; **Robert L. Haynes,** American Standard, Louisville, Ky.; **S. E. Davis,** U. S. Pipe & Foundry Co., Bessemer, Ala. Standing: **J. E. Granger,** U. S. Pipe & Foundry Co., Birmingham, Ala.; **James L. Lloyd,** Lee Bros., Anniston, Ala.; **R. A. Miller,** James B. Clow & Sons, In., Birmingham, Ala.

Michigan Regional Brings Students Into Its Program

■ Increased emphasis will be placed on student participation at the 1959 Michigan Regional Foundry Conference to be held Oct. 8-9 at the Pantlind Hotel, Grand Rapids, Mich.

Among the plans are:

■ Inclusion of the following schools in the conference; Lawrence Institute of Technology, Wayne University, University of Michigan, Michigan State University, Western Michigan University and Benton Harbor Technical Institute.

■ Extension of invitation to three science counsellors in each of the four sponsoring-chapter areas.

■ Seating of students with foundrymen during luncheons. Pre-arranged plan will be used.

Portion of students of T&RI course given in Birmingham, Ala., in cooperation with the **AFS Birmingham Chapter.** Classes were held at Dinkler-Tutwiler Hotel.

Instructor **Charles Locke,** Crucible Steel Castings Co., Cleveland, explains formula to students in T&RI Gating & Risering of Castings held Feb. 23-25 in Birmingham, Ala. Others are: **Homer T. Herrington,** American Coolair Corp., Jacksonville, Fla.; **John Garcia,** Commerial Shearing & Stamping Co., Youngstown, Ohio; **H. Otey Meriwether, Jr.,** Lynchburg Foundry Co., Lynchburg, Va.; **Lee T. Lynn,** Pekor Iron Works, Inc., Columbus, Ga.

Core Stickiness Committee to Summarize its Research

■ Investigation into the problem of core stickiness has been completed by the Sand Division Core Stickiness Committee and the findings will be summarized in a technical paper designed to give operating personnel help in solving field problems.

Included will be:

- Summary of work to date and recommendations.
- General items relating to stickiness which apply to all processes. Discussed will be oil-cereal binders, water soluble binders and shell cores and molds.

Joseph Replaces Levi on Cupola Committee

■ Carl J. Joseph, Central Foundry Div., GMC, Saginaw, Mich., is now chairman of the AFS Cupola Advisory Committee. Joseph replaces W. W. Levi, Lynchburg Foundry Co., Radford, Va., who resigned.

Malleable Melting Variables Book Sums Up AFS-Sponsored Research

■ Effects of melting variables on the properties of malleable iron have been compiled in the new AFS publication MELTING VARIABLE EFFECTS ON MALLEABLE IRON PROPERTIES. The 29-p book, authored by R. W. Heine, University of Wisconsin, Madison, Wis., represents a report of research projects sponsored by the AFS Malleable Division over a seven-year period.

Investigation of chemical reactions during melting shows five major variables are associated with analysis changes. These are:

- Oxidizing melting furnace atmospheres.
- Neutral or reducing melting furnace atmospheres.
- Oxidizing metal charges.
- Melting-down time.
- Temperature.

Details and interpretations of the principles, conclusions and their application to practical melting problems are explained in simplified text. Thermodynamics and numerous calculations which might be used to support the data have been avoided to stress the summary and interpretation of the conclusions and principles.

Sections are devoted to: chemical reactions in melting, mottling tendency and melting practices, annealability and melting pratices, effect of melting variables on tensile properties, fluidity, hot tearing, pinholes, nodule number and residual elements.

T&RI Metallography of Ferrous Metals Course

Students in T&RI **Metallography of Ferrous Metals** course observe equipment at Adolph I. Buehler, Inc. Three-day course included two days of classwork and one day in laboratory.

David Hansen, Wells Mfg. Co., Skokie, Ill. makes observations during T&RI Metallography of Ferrous Metals course presented March 9-11 in Chicago and Evanston, Ill. Watching are **Charles Desillier,** Arwood Precision Casting Corp., Groton, Conn.; **Ronald L. Hooker,** Golden Foundry Co., Columbus, Ind.; instructor **Raymond Michaels,** Adolph I. Buehler, Inc., Evanston, Ill.; **Sigmund Willinger,** Owens-Illinois Glass Co., Toledo, Ohio.

Instructor **Cornelius Johnson,** Adolph I. Buehler, Inc., Evanston, Ill., demonstrates sample preparation techniques in laboratory session of Metallography of Ferrous Metals course. Watching are **H. J. DeRolf,** Pittsburgh Coke & Chemical Co., Pittsburgh, Pa.; **Tom Dacus,** Acme Foundry & Machine Co., Blackwell, Okla.; **Donald Birtwistle,** Great Lakes Founders & Machine Corp., Ludington, Mich.; **James T. Kirsh**-Kirsh Foundry, Inc., Beaver Dam, Wis. Course was presented in 1958 and repeated in 1959 as a result of comments given by students in evaluating study.

major AFS meetings

MAY

21 . . . **AFS Division Meetings,** Annual Review of Executive Committees, Program & Papers Committees, Sherman Hotel, Chicago.
22 . . . **AFS Technical Council,** Annual Meeting, Sherman Hotel, Chicago.
25 . . . **AFS Publications Committee,** Annual Meeting, Sherman Hotel, Chicago.

JUNE

11-12 . . . **15th Annual Chapter Officers Conference**—AFS Headquarters, Des Plaines, Ill. and Sherman Hotel, Chicago.
15 . . . **T&RI Research Committee,** Annual Meeting Sherman Hotel, Chicago.
18-20 . . . **4th Annual Foundry Instructors Seminar,** University of Illinois, Urbana, Ill.
25-27 . . . **Penn State Foundry Conference,** Pennsylvania State University, University Park, Pa.; Sponsors: AFS Central New York, Chesapeake, Eastern New York, Metropolitan, Northwestern Pennsylvania, Ontario, Philadelphia, Pittsburgh, Rochester, Western New York and Penn State University Student Chapters; Conestoga Foundrymen's Association, Lehigh Valley Foundrymen's Association, Reading Foundrymen's Association.

JULY

21-22 . . . **AFS Finance Committee,** Annual Budget Meeting, Union League Club, Chicago.

AUGUST

6 . . . **AFS Executive Committee,** Special Meeting, (location to be announced).
6-7 . . . **AFS Board of Directors,** Annual Meeting, (location to be announced).

SEPTEMBER

23 . . . **Regional Meeting,** Region 6, University of Missouri, School of Mines and Metallurgy, Rolla, Mo.
24-25 . . . **AFS Missouri Valley Regional Foundry Conference,** University of Missouri, School of Mines and Metallurgy, Rolla, Mo. Sponsors: Mo-Kan, St. Louis, Tri-State Chapters and Missouri School of Mines Chapter with University of Missouri School of Mines and Metallurgy.

Wentworth Institute Students Form Latest Society Chapter

■ Admittance to the American Foundrymen's Society has been granted to the Wentworth Institute Student Chapter. Approval of the chapter was made by the AFS Board of Directors with presentation of the charter made April 2 in Boston at a Presidents' Convocation with the student body in attendance. Awarding of the certificate was made by AFS Secretary A. B. Sinnett.

Officers of the chapter are Chairman Anthony J. Ricci; Vice-Chairman Walter LoPriore. J. Gerin Sylvia, foundry instructor at Wentworth Institute, is the faculty advisor and Herbert H. Klein, Klein-Farris Co., Boston and member of the AFS New England Chapter, is the industrial advisor. Both Sylvia and Klein with AFS National Director Henry G. Stenberg, have been active in the chapter's formation.

Forty-one students are charter members. They are:

Roger S. Abbott, Donald E. Bardsley, Stanley T. Beers, Paul M. Bloomfield, Richard Bornstein, Walter Cabe, Richard Cotonia, Robert Coven, James M. Curran, Renald A. DuBois.

Matthew J. Faino, William F. Finney, Richard Forbes, Bernard P. Gaffney, Joseph W. Galvam, Jr., Robert E. Jurgel, Gerald R. Langevin, John L. Lane, Richard Lederman.

Walter LoPriore, Ronald Mafera, Warren C. Morse, Thomas E. Naylor, Jr., Richard E. Poirier, David Poole, Patrick F. Rachvazzo, Andre M. Richard, Anthony J. Ricci, Robert J. Rock, G. R. Salvia.

Roderick Schmaling, Frank N. Seimone, Thomas Silve, Jr., David J. Simm, Walter Sommer, Neil B. Taylor, William H. Urquhart, Nicola A. Vacca, Francis Webb, Richard J. Whitehead, Paul H. Wirzburger.

Rochester Chapter

New Non-Ferrous Developments

■ New developments in various phases of non-ferrous foundry procedure were discussed at the February meeting by Joseph D. Allen, Jr., Federated Metals Div., American Smelting & Refining Co. A portion of the talk was devoted to methods of de-gassing aluminum and testing for the presence of gas in aluminum heats.

—Thomas B. DeStefani

The future of foundries and tomorrow's automobiles was outlined at the February meeting of the **Philadelphia Chapter** by D. J. Henry, General Motors Corp., Detroit. Left to right: Chapter Vice-Chairman **E. A. Zeeb,** Dodge Steel Co., Philadelphia; speaker **D. J. Henry;** Technical Chairman **K. H. Kostenbader,** Bethlehem Steel. **—Leo Houser, Ed Klank**

A new approach to marketing of castings was explained at the February meeting of the **Central Indiana** Chapter by E. E. Braun, Central Foundry Div., GMC, Saginaw, Mich. Left to right are: speaker **Braun; Allen Evans,** International Harvester Co., Indianapolis; **Sam Johnson,** International Harvester Co., Indianapolis. Meeting was held at Athenaeum Turners. **—Wm. R. Patrick**

Cincinnati Chapter

Hears Talk on Sand Segregation

■ Sand segregation, its causes and effects on sand and castings was described at the March meeting by T. W. Seaton, American Silica Sand Co., Ottawa, Ill.

T. W. Seaton

Seaton emphasized that sand segregates every time it is moved. How sand is stored and moved has a direct effect on casting quality. Various methods of minimizing sand segregation were cited by Seaton from AFS research. *—J. D. Claffey*

Prof. **J. F. Wallace,** Case Institute of Technology, Cleveland, who addressed **Cincinnati** Chapter on gating gray iron castings, explaining theoretical requirements and their application in the commercial field.

—J. D. Claffey

San Antonio Section

Sees Film on Steelmaking

■ A film, "Highlights in Steelmaking" was presented at the February meeting. Covered were various types of furnaces and steels and operating procedures.

Western New York Chapter

Utilizing Latest Developments

■ Considerable progress has been made in casting processes and techniques in recent years, progressive foundrymen must study these methods and select those best suited for their operations to remain competitive. These recent advances were outlined by Alfred B. Steck, Metallurgical Associates, Inc., New York, at the March meeting. *—Don Kreuder*

Past Chapter Chairmen were honored by the **Ontario Chapter** at its February meeting. Shown are **F. W. Kellam** (1956-57); **M. McQuiggan; A. Reyburn** (1952-53); **C. C. McDonald** (1943-44); **J. H. King** (1949-50); **F. J. Rutherford** (1954-55); **M. N. Tallman** (1950-51); **W. H. L. Bryce** (1955-56); **J. Sully** (1938-39); **T. D. Barnes** (1945-46); **R. A. Woods** (1948-49); **J. A. Wotherspoon** (1946-47). J. Sully was the chapter's first chairmen and a past National Director. J. H. King is also a past National Director. McQuiggan was formerly Eastern Canada Chapter Chairman and now lives in Ontario. **—Vince Furlong**

Attending February meeting of **Northwestern Pennsylvania** Chapter was group from Lang Electric Foundry, Edinboro, Pa. Left to right: **C. Williams, R. Sanders, E. Schrieber, A. Kelly, J. Smith, T. Maziarz.**

Epoxy resins and their uses in the foundry were discussed at the March meeting of the **Western Michigan Chapter.** Shown are: **Joe Brooks,** Sparta Div., Muskegon Piston Ring Co., Sparta, Mich., and former chapter chairman; **Fred Hagquist** and **William Frid,** guest speakers from Tylene Plastics, Inc., Michigan City, Ind.; Chapter Chairman **J. J. Cannon,** Enterprise Brass Works, Muskegon, Mich. **—Dan Connell**

Ralph Petersen, Central Pattern Co., St. Louis, hands out prizes to winners in the **St. Louis Chapter** apprentice contest competition.

Sigfrid Johnson, foundry superintendent, Woodruff & Edwards Co., Elgin, Ill., shown meeting King Gustavus VI of Sweden. Johnson has been at Woodruff & Edwards since 1920 and foundry superintendent for the past 12 years.

George DiSylvestro (left) American Colloid Co., Skokie, Ill., addressed St. Louis Chapter in February on **Veining & Penetration.** On right is technical chairman **Everett Hart,** East St. Louis Castings Co., East St. Louis, Ill. **—Vince Boemer**

George Pfaff, Wheelabrator Corp., Mishawaka, Ind., addressed the **Tennessee Chapter** in February on "Reducing Blast Cleaning Costs." Shown are: Chapter Vice-Chairman **Charles E. Seman,** Crane Co., Chattanooga, Tenn.; Chapter Treasurer **James W. Richie, Jr.,** Foundry Pattern Service, Chattanooga, Tenn.; speaker **Pfaff;** Chapter Chairman **W. L. Austin,** U. S. Pipe & Foundry Co., Chattanooga, Tenn. **—H. G. Nelson**

chapter news

Texas Chapter

Mechanization in Small Foundry

■ Mechanization problems in a small foundry were explained at the February meeting by George T. Dupre, National Engineering Co., Chicago. Attending were 144 foundrymen, the largest attendance of the year.

Dupre traced the gradual mechanization of a small foundry, showing how each piece of equipment, as it was acquired, would fit into the final arrangement. Slides were used to demonstrate the equipment and its utilization.

Dupre also outlined the use of high and low pressure air for conveying core sand, molding sand and facing sands. Dupre then concluded his talk by presenting data on the amount of free air required to deliver a cubic foot of each of the sands.

—Harold H. Judson

Central Ohio Chapter

Hears Talk on Die Casting

■ Die castings and problems associated with die castings were explained at the February meeting by L. W. Payne, Ohio Die Casting Corp., Columbus, Ohio.

Payne traced the history of the die casting industry and of the recent developments. Chapter Chairman Dallas March, Cooper-Bessemer Corp., Mt. Vernon, Ohio, presided with Vice-Chairman Harry E. Grabel, Ohio Malleable Div., Dayton Malleable Iron Co., Columbus, Ohio, serving as technical chairman.

—Joseph A. Riley, Jr.

Four-man group from Erie Bronze Co., Erie, Pa., attended February meeting of **Northwestern Pennsylvania Chapter.** Left to right: **Bill Piper, Zack Miller, Peter Eller, Howard Diemert.** —Walt Napp

Mexico Chapter

Elects Officers, Directors

■ Election of officers and directors was conducted at the chapter's January meeting.

Chairman—Luis Delgado Vega, Cia. Proveedora de Industries S. A. Mexio D. F., Mexico.

Vice-Chairman—Enrique Leon Andrade, Teziutlan Copper Co., S. A. Mexico D. F., Mexico.

Secretary—Jose A. Perez Casas, La Consolidada S. A., Mexico D. F., Mexico.

Treasurer—Juan Latapi Sarre, Fundiciones de Hierro y Acero S. A., Mexico D. F., Mexico.

Directors(Terms expire 1962)—Jorge Duarte, Albert Doerr Co. S. A., Mexico, D. F., Mexico; Alejandro A. Gonzalez, Jr., Fundidora y Laminadora S. A., Mazatlan Sinaloa, Mexico; Joseph Krishon, Mueller Brass de Mexico S. A., Toluca, Mexico.

Northwestern Pennsylvania Chapter's February speaker, **H. L. Smith,** Federated Metals Div., American Smelting & Refining Co., Whiting, Ind., uses board to demonstrate a point. Smith addressed foundrymen from the Erie, Pa., area on the subject of "Brass & Bronze Foundry Practice—Especially Melting Techniques." The meeting was held at the Amity Inn., Erie, Pa. —Walt Napp

Philadelphia foundrymen welcome new members training at Bethlehem Steel Co., Bethlehem, Pa. Left to right: **D. E. Best,** Bethlehem Steel; **Shivaji Chaubey; Ranjit Kumar Dasgupta; J. Muir,** Bethlehem Steel.

British Columbia Chapter

Hears Talk on Air Set Process

■ Practical experiences with the cold set process and use of slag and glass wool in core sands was presented at the February meeting by Ray Silva, Fairbanks-Morse Co., Pomona, Calif. Chapter Chairman J. T. Hornby, Balfour Guthrie (Canada) Ltd., Vancouver, B. C., presided. N. D. Amundsen, Terminal City Iron Works, Ltd., Vancouver, B. C., served as technical chairman. *—D. K. Faurschou*

Philadelphia Director **E. X. Enderlein** (center), H. G. Enderlein Co., Philadelphia, with four Enderlein Co. supervisors.
—Leo Houser and Ed Klank

AFS Chapters frequently hold joint meetings with other societies. In the fall, **Twin City** members meet with A.S.M. members. Twin City Vice-Chairman **Carter De Laittre** is on left with A.S.M. Minnesota Chapter Chairman **Dr. Morris E. Nicholson,** University of Minnesota on right. **F. G. Emrich** (center) was speaker.

Chapter Chairman

W. C. Pickles
Chairman
St. Louis

Alabama Student Chapter Holds Show

■ Several hundred engineering students and approximately 125 foundrymen from the AFS Birmingham Chapter attended a show of foundry control instruments March 13 at the University of Alabama, University, Ala.

The show, sponsored by the University of Alabama Student Chapter, was held in the foundry building of the Metallurgical Engineering department.

Automatic carbon and sulphur determinators, pyrometers, radiographic and other non-destructive equipment was demonstrated. Metallurgical engineering students demonstrated metallographic hardness testing and other mechanical testing equipment.

Dean James R. Cudworth described the proposed new Mineral Industries building to AFS members attending the luncheon. The building will house the metallurgical, chemical and mining engineering departments and will cost approximately $1,500,000, excluding equipment.

Harry D. Bradshaw was presented with a certificate in recognition of his receiving the Wheelabrator graduate fellowship, a cash fellowship of $1500.

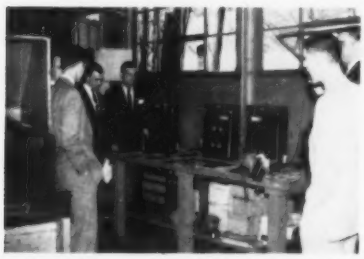
In addition to activities at the University, students are invited to attend meetings of the Birmingham Chapter. The student chapter co-sponsors the annual Southeastern Regional Foundry Conference with the Birmingham and Tennessee Chapters.

This year's speakers at the Southeastern Regional Foundry Conference were awarded cast fruit bowls made by members of the student chapter at the University.

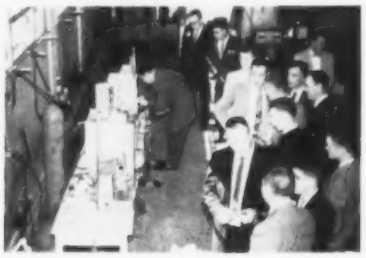
Prof. Warren C. Jeffery, University of Alabama, is the Student Chapter Faculty Advisor and L. H. Durdin, Dixie Bronze Co., Birmingham, Ala., is the industrial advisor.

Victor Rowell, Harry W. Dietert Co., shown on right, demonstrates new sand testing equipment to metallurgical students.

A. B. Albertoli, Magnaflux Corp., seated, explains non-destructive testing test equipment to engineering students.



Doug Ballard, Picker X-Ray Corp., behind viewer, discusses radiography at show of foundry control instruments. —**D. E. McGill**



A. E. Borrelli, Laboratory Equipment Corp., demonstrates automatic carbon and sulphur determinators.

Participants at the **St. Louis Chapter** March meeting nodular iron panel discussion: **Al Schnipper,** Excelsior Foundry Co., Belleville, Ill.; **R. L. Clark,** Century Foundry Co., St. Louis; moderator **John O'Meara,** Banner Iron Works, St. Louis; **Tony Sveglich,** Century Foundry Co.; **W. Myerson,** formerly of Century Foundry Co. —**Vince Boemer**

Shown at March meeting of **Western New York Chapter:** Chapter Secretary **R. E. Turner,** Queen City Sand & Supply Co.; **P. S. Savage,** McCallum Bronze Co., Inc.; Technical Chairman **Oscar Pietsch,** Pohlman Foundry Co.; **J. M. Clifford,** Atlas Steel Casting Co. —**Walter Napp**

New England Chapter

Aluminum Castings Future

■ The future for aluminum castings was presented at the March meeting by D. L. LaVelle, Federated Metals Div., American & Smelting Co., South Plainfield, N.J. Ninety foundrymen attended the meeting. Chapter President William N. Ohlson, Draper Corp., Hopedale, Mass, presided.

—*F. S. Holway*

Tri-State March speaker **F. W. Hanson** (left) shown with **Charles Gilchrist,** Oklahoma Steel Castings Co., Tulsa, Okla.

W. H. Ohlson
Chairman
New England

W. H. Faust
Chairman
Central Indiana

chapter news

Oregon Chapter

Has Visit by Wm. W. Maloney

■ "We can't get you back there, so we're coming here," said Wm. W. Maloney, AFS General Manager, addressing the March meeting of the Oregon Chapter.

Maloney then explained that the 1961 AFS National Convention would be held in San Francisco—the first time the Convention has been held on the West Coast.

James W. Smith, Oregon Metallurgical Corp., Albany, Ore., discussed developments in melting and casting reactive metals. Casting of titanium and zirconium is still in the pioneer stage. Smith explained vacuum melting, pouring and manufacture and use of molds. *—Bill Walkins*

Oregon Chapter was visited in March by AFS General Manager **Wm. W. Maloney** in a tour through the west, southwest and northwestern sections. Other are **J. W. Smith,** Oregon Metallurgical Corp., Albany, Ore., and technical speaker for the evening and Oregon Chapter Chairman **Robert M. Burns,** Pacific Light Metals Foundry Co., Div. Pacific Chain & Mfg. Co., Portland, Ore.

A real Oregon beaver is sported by **Phil Laugen,** Oregon Steel Foundry Co., Portland, Ore., and former chapter chairman. State of Oregon is celebrating centennial this year but **James W. Smith,** Oregon Metallurgical Corp., Albany, Ore., and Chapter Vice-Chairman **Carl Mattson,** Dependable Pattern Works, Portland, Ore., figure to lose the contest by more than a hair.

Central Ohio Chapter

Hears Talk on CO_2 Process

■ Progress and development of CO_2 coremaking and molding at Ohio Steel Foundry Co., Springfield, Ohio, were presented at the March meeting by J. W. Gillespie. Early experiments were discussed including use of various sands, binders and procedures.

Currently a rapid mixer and core shooter is used. Cores and molds are automatically gassed at a separate station using 40-50 psi. Advantages of the process include better finish, better dimensional control, elimination of driers and bedding sand and more economical core production.

—Joseph A. Riley, Jr.

S. L. Gertsman, Dept. of Mines & Technical Surveys, Ottawa, Ont., Canada, technical speaker at the **Ontario Chapter** March meeting receives congratulations from Chapter Publicity Reporter **Vincent H. Furlong** (left) Foundry Services (Canada) Ltd., Guelph, Ont. Others are **W. R. Weir,** Dominion Foundries & Steel Ltd., Hamilton, Ont. and **Don Barnes, Jr.,** Don Barnes, Ltd., Hamilton, Ont.

Speaker at March meeting of **Western New York** Chapter, **Alfred B. Steck** (center), Metallurgical Associates, Inc., flanked by Chapter Chairman **L. B. Polen,** Allegheny Ludlum Steel Corp. and Vice-Chairman **A. J. Heysel,** E. J. Woodison Co.

Tri State Chapter

Induction Furnace Melting

■ Uses of induction furnaces and established practices for both lining and operating were outlined at the March meeting by F. W. Hanson, Union Carbide Metal Co., Houston, Texas. Other topics included recoveries of alloys and advantages and disadvantages of induction melting.

—Leslie O'Brien

Central Ohio Chapter Chairman **Dallas March** presents **Nard Stapf** with membership chairman award. Chapter achieved membership goal 1957-58.

B. C. Yearley, National Malleable & Steel Castings Co., Cleveland, who addressed **Wisconsin Chapter** in March on "Gating & Feeding Malleable Castings." **—Bob DeBroux**

Tri-State March meeting has this table representing Oklahoma: **Richard Gilmore,** Gilmore Pattern Works, Tulsa; **Rex Hill,** Progressive Brass Mfg. Co., Tulsa, Okla.; **Roger Williams,** Cities Service Oil Co., Oklahoma City; Chapter Chairman **Emmett Hines,** Nemco Foundry Co., Tulsa; **Leo Masching,** Frank Wheatley Pump & Valve Co., Tulsa; Chapter Secretary **Jackson Dean,** Nelson Electric Mfg. Co., Tulsa.

Timberline Chapter

Has Visit By National Officers

■ Timberline Chapter in March was host to AFS President L. H. Durdin, AFS National Director Webb L. Kammerer and AFS General Manager Wm. W. Maloney. Durdin was awarded a gavel by the chapter.

Certificates of appreciation were awarded to past chapter chairmen. Receiving awards were J. L. Higson, Clyde Penney, Curtis Drake, John Horner, Roger Hedgebeck, James Schumuck, Byron McPherson, William Manske, Darrell Durant, David Card and Joseph Taleck. —*A. W. Patten*

Former AFS National Director **C. C. Drake** and Denver foundrymen at Timberline meeting.

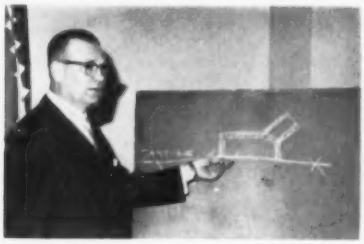
H. Weaver, Brillion Iron Works, Brillion, Wis., who addressed **Wisconsin Chapter** in March on "Improving Your Shell Molding Operations."

Attending Timberline Chapter March meeting were National Director **Webb Kammerer** and General Manager **Wm. W. Maloney** in background. In front is **Nick Primavera,** C. S. Card Iron Works Co., Denver, Colo.

N. Stamm, Belle City Malleable Iron Co., Racine, Wis., who addressed **Wisconsin Chapter** in March on "Cleaning Room Problems and Our Solutions." —**Bob DeBroux**

Central Ohio Chapter Chairman **Dallas Marsh** (left) presents past chairman award to **Paul Eubanks,** chairman 1957-58.

President **L. H. Durdin,** Timberline Chapter Chairman **Joseph Taleck** and National Director **Webb Kammerer** at chapter's March meeting.



M. C. Ehrman, Jr., International Harvester Co., Milwaukee, who addressed **Wisconsin Chapter** in March on "Engineering Design Effects on Castings, Product Costs and Pattern Equipment Costs."

Enjoying joke at **Western New York** March meeting are **A. A. Boisvert** and **R. A. Snyder,** both of American Radiator & Standard Sanitary Corp. —**Walter Napp**

Fred Kramer (left), Kramer Industrial Supply Co., Denver, Colo., discusses foundry business with AFS **President Durdin.**

L. J. Woehlke, Wisconsin Chapter Chairman, addresses March meeting. —**Bob DeBroux**

Just prior to start of **Tri-State** March meeting three foundrymen conduct smiling contest. They are: **Quentin David** and **Frank Scaggs** of Oklahoma Steel Castings Co., Tulsa, Okla., and **Rex Hill,** Progressive Brass Mfg. Co., Tulsa.

Ontario Chapter

Hears Talk on Metal Penetration

■ Slides and graphs supplemented S. L. Gertsman's technical talk at the March meeting of the Ontario Chapter. Gertsman, with the Department of Mines & Technical Surveys, Ottawa, Ont., Canada, talked on metal penetration and explained the designing of a casting to study the governing factors. The casting has been adopted as an AFS tentative standard.

—John P. Schlathau

Two past national directors attending **Northwestern Pennsylvania** meeting. Shown are: **Lloyd Wright,** National-U.S. Radiator Corp., Johnstown, Pa.; **Tom Eagan,** Cooper-Bessemer Corp., Mt. Vernon, Ohio.

Central New York Chapter

What's New in CO_2?

■ Despite extremely poor weather conditions, 77 foundrymen attended the March meeting to hear William J. White, Carver Foundry Products, who observed that although the CO_2 process was first used in core work it appears to have even greater possibilities in molding. Advantages of the process include better accuracy and collapsibility control.

Two high school students and two instructors were guests. They were invited by the education committee headed by Philip Benevento, Oberdorfer Foundries, Inc., Syracuse, N.Y.

—Carl Diehl

Attending **Northwestern Pennsylvania** Chapter meeting, all from Oil Well Supply Co., **Frank Richards, Ed Pearson, William Schell** and **Sam Bowen.** —Walter Napp

Connecticut Chapter

Conducts Sand School at Yale

■ Seventy-five foundrymen attended a four-day school held during March at the Hammond laboratory of Yale University. The school was directed by Victor Rowell, Harry W. Dietert Co., Detroit. *—R. J. Brandt*

Mechanization in jobbing foundries was described at the February meeting of the **Connecticut** Chapter by Glenn Merrefield, Giffels & Rossetti Co., Detroit. Merrefield pointed out various items to be considered in planning mechanization of foundries. He emphasized the importance of building control measures into today's foundries. Standing are Chapter President **Myron Gould,** speaker **Merrefield** and Program Chairman **Robert J. Brandt.**

afs chapter meetings

MAY

Birmingham District . . May 8 . . Thomas Jefferson Hotel, Birmingham, Ala. . . . J. Delisa, General Electric Co., *"Nondestructive Testing of Castings."*

British Columbia . . May 23 . . Birch Bay . . *Spring Golf Tournament* . . **May 29 . .** Leon's, Vancouver, B. C. . . *Banquet.*

Canton District . . *No Meeting.*

Central Illinois . . May 4 . . Vonachen's Junction, Peoria, Ill. . . . C. E. Fausel, Central Foundry Div., GMC, *"Preventive Maintenance,"* and H. J. Weber, AFS, *"Air Pollution Laws Affecting Foundries."*

Central Indiana . . May 4 . . Athenaeum, Indianapolis . . *Panel:* J. A. Crumley, Deere & Co.; G. R. Slick, Beckett Bronze Co.; W. M. Grimes, Gartland Foundry Co.; H. W. Carmichael, Nonferrous Foundries, Inc.; O. L. Wilhelm, Delco Remy Div., GMC. *Moderator:* R. Fickenworth, Bruce-Conreaux Co., *"Know Your Local Area Foundries" and Past Chairmen's Night.*

Central Michigan . . May 20 . . Hart Hotel, Battle Creek, Mich.

Central New York . . May 8 . . Drumlin's Country Club, Syracuse, N.Y.

Central Ohio . . May 11 . . Seneca Hotel Columbus, Ohio.

Chesapeake . . *No Meeting.*

Chicago . . May 4 . . Chicago Bar Association, Chicago . . A. Homberger, International Automation Corp. *Film, "Buhrer Automated Molding & Pouring Methods."*

Cincinnati District . . May 11 . . Hotel Alms, Cincinnati . . B. D. Claffey, G.H.R. Foundry, Div. Dayton Malleable Iron Co., *"Shell Molding & Shell Coremaking."*

Connecticut . . May 26 . . Indian Hill Country Club, New Britain, Conn. . . . C. E. Wenninger, Beardsley & Piper Div., Pettibone Mulliken Corp., *"Sand Reclamation."*

Corn Belt . . May 1 . . Steeple House, Beatrice, Neb.

Detroit . . May 21 . . Wolverine Hotel, Detroit . . E. J. Mapes, Pickands Mather & Co., *"Horizons North."*

Eastern Canada . . May 25 . . Sheraton Mt. Royal Hotel, Montreal, Que. . . *Presentation of Winning Entries, Chapter Paper Writing Competition.*

Eastern New York . . May 19 . . Panetta's Restaurant, Menands, N.Y.

Metropolitan . . May 4 . . Essex House, Newark, N.J. . . . J. Mikulak, Worthington Corp. and L. Palmer, American Metaseal Corp., *"Welding & Impregnation of Pressure Castings."*

Mexico . . May 25 . . Ave. Chapultepec 414, Mexico D.F. . . . J. A. Perez Casas, La Consolidada S.A., *"Chemical Control in Steel Foundries."*

Michiana . . May 9 . . Elkhart, Ind. . . *Ladies' Night.*

Mid-South . . May 8 . . Claridge Hotel, Memphis, Tenn. . . *Election of Officers.*

Mo-Kan . . May 1 . . Fairfax Airport, Kansas City, Kans.

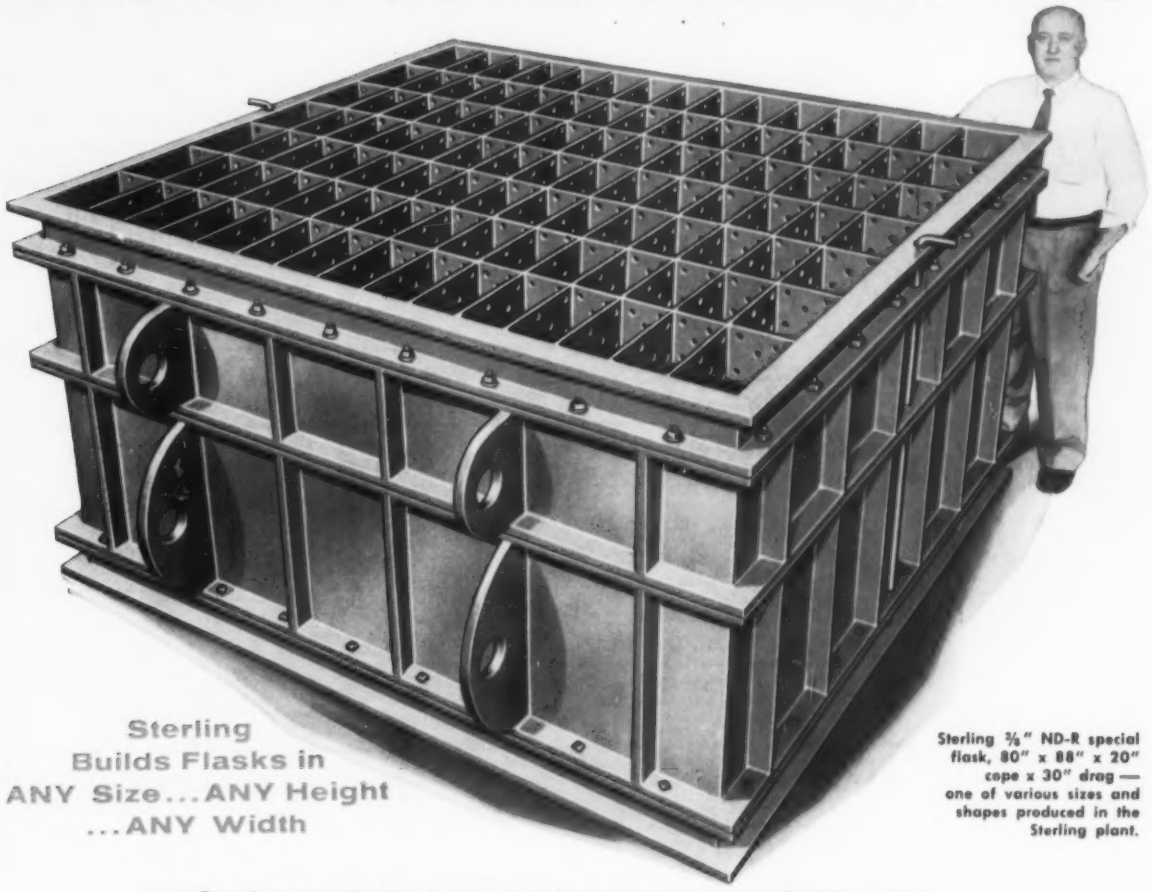
New England . . May 13 . . University Club, Boston.

Northeastern Ohio . . May 14 . . Tudor Arms Hotel, Cleveland . . *Recognition Night—Apprentices, Old Timers, National Officers, Past Chairmen.*

Continued on page 138

BIG 3½ TON FLASK

Well-known Pennsylvania Grey Iron Foundry Uses Sterling Flasks for producing Massive 4000 lb. Castings



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Sterling

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METAL	RCI PRODUCTS	DESCRIPTION	OUTSTANDING FEATURES
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	FOUNDREZ 7600, 7601, 7605	LIQUID AMINO CORE BINDING RESINS	RAPID COLLAPSIBILITY FAST BAKE — LESS SMOKING
	CO-RELEES 7300	LIQUID SAND CONDITIONER	EXCELLENT SAND WORKABILITY
	coRCIment 7990, 7991, 7992, 7993	LIQUID OLEORESINOUS CORE BINDERS	BROAD BAKING RANGE
	FOUNDREZ 7150, 7151	LIQUID PHENOLIC RESINS FOR SHELL COREMAKING	UNUSUAL STABILITY
	FOUNDREZ 7500, 7504, 7506, 7555	POWDERED PHENOLIC RESINS FOR SHELL MOLDING	SELF-ACTIVATION
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REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Circle No. 155, Page 167-168

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You'll have fewer rejects—far better quality castings when you switch to Koppers Premium Foundry Coke. Car after car, Koppers delivers a superior coke that's absolutely *uniform* in *size, strength, structure* and *chemical analysis.* Because of the higher carbon content in Koppers Premium Foundry Coke, the foundryman can maintain a higher temperature range which increases the cleanliness of the iron. This in turn, helps reduce fuel consumption—means lower operating costs all around. Next time order Koppers Premium Foundry Coke. Available anywhere in the U.S. or Canada in sizes to meet your needs. Koppers Company, Inc., Pittsburgh, Pa.

WE CHECK EACH DAY'S RUN to make certain you get foundry coke of the exact size and chemistry that is most efficient for the job. Analyses are available to your foundry on request.

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(First issue Sept. 15, 1959)

The only complete Buyers Directory serving the Metal Casting Industry

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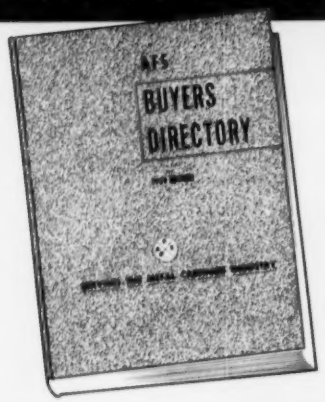
Advertising deadline July 1



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AFS Chapter Meetings

Continued from Page 134

Northern California . . May 11 . . Spenger's, Berkeley, Calif. . . *Heat Treat Panel.*

Northern Illinois & Southern Wisconsin . . May 9 . . Beloit Country Club, Beloit, Wis. . . *Golf Outing.*

Northwestern Pennsylvania . . May 25 . . Amity Inn, Erie, Pa. . . F. H. Dettore, G. E. Smith, Inc., *"Kold Set Practices."*

Ontario . . May 29 . . Royal York Hotel, Toronto, Ont. . . W. Hepburn, John T. Hepburn Ltd., *"Co-ordinated Control of Foundry Operations."*

Oregon . . May 20 . . Heathman Hotel, Portland, Ore. . . *Business Meeting. Program in Conjunction with Oregon State College Student Chapter.*

Philadelphia . . May 8 . . Engineers' Club, Philadelphia . . M. A. Cavanaugh, Budd Co., *"Preventive Maintenance."*

Piedmont . . May 1 . . Hotel O'Henry, Greensboro, N.C. . . R. Carlson, American Cast Iron Pipe Co., *"Cupola Operations."*

Pittsburgh . . May 18 . . Webster Hall Hotel, Pittsburgh, Pa. . . J. W. Early, J. S. McCormick Co., Educational Meeting, also Honoring 50-year Men.

Quad City . . May 18 . . LeClaire Hotel, Moline, Ill. . . G. O. Pfaff, Wheelabrator Corp., *"Reducing Blast Cleaning Costs."*

Rochester . . May 5 . . Manger Hotel, Rochester, N.Y. . . *Election of Officers.*

Saginaw Valley . . May 7 . . Fischer's Hotel, Frankenmuth, Mich. . . C. C. Sigerfoos, Michigan State University, *"Central American Foundries."*

St. Louis District . . May 14 . . Edmond's Restaurant, St. Louis . . C. V. Nass, Beardsley & Piper Div., Pettibone Mulliken Corp., *"Mechanization of Molding."*

Southern California . . May 8 . . Rodger Young Auditorium, Los Angeles . . K. F. Sheckler, Calmo Engineering Co., *"Refractories—Uses in the Foundry."*

Tennessee . . May 22 . . Patten Hotel, Chattanooga, Tenn. . . V. D. Annakin, Ph.D., Indiana State Teachers College, *"Backdrop for Survival." Ladies Night.*

Texas . . May 15 . . Fredonia Hotel, Nacogdoches, Texas.

Timberline . . May 9 . . Oxford Hotel, Denver, Colo.

Toledo . . *No Meeting.*

Tri-State . . May 8 . . Alvin Plaza Hotel, Tulsa, Okla. . . W. R. Jaeschke, Whiting Corp., *"Cupola Practice."*

Twin City . . May 12 . . Jax Restaurant, Minneapolis . . O. J. Myers, Reichhold Chemicals, Inc., *"Resin Core Binders."*

Utah . . *No Meeting.*

Washington . . May 14 . . Engineers' Club, Seattle . . *"Cleaning Room Abrasives, Grinding Wheels & Metal Shot," by Pacific Grinding Wheel Co. and Wheelabrator Corp.*

Western Michigan . . May 4 . . Bill Stern's Restaurant, Muskegon, Mich. . . E. Hines, *"Foundry Costs."*

Western New York . . May 7 . . Sheraton Hotel, Buffalo, N.Y. . . *Annual Smorgasbord Dinner.*

Wisconsin . . May 8 . . Schroeder Hotel, Milwaukee . . *Old Timers' and Apprentices' Night.*

JUNE

Central New York . . June 20 . . Hinerwadel's Grove, N. Syracuse, N.Y. . . *Clam Bake.*

Chesapeake . . June 5 . . Hagerstown, Md. . . *Plant Visitation to Pangborn Corp. and Fairchild Engine & Aircraft Corp.*

Cincinnati District . . June 8 . . Walnut Grove Country Club, Dayton, Ohio . . *Golf Outing and Picnic.*

Mexico . . June 29 . . Ave. Chapultepec 414, Mexico, D.F. . . R. Jauregui, Aceros Tepeyac S.A., *"Practical Metallography."*

Northern California . . June 5 . . *Ladies' Night.*

Oregon . . June 17 . . Heathman Hotel, Portland, Ore.

Saginaw Valley . . June 6 . . *Annual Outing.*

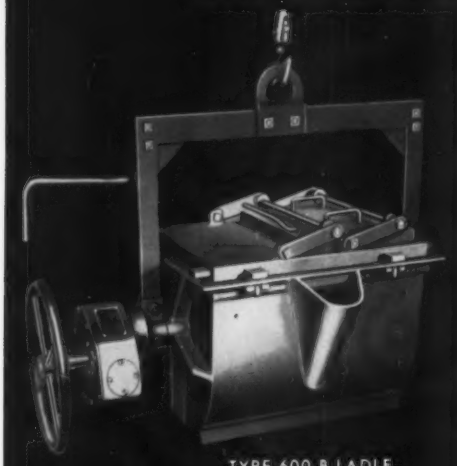
Southern California . . June 5 . . Rodger Young Auditorium, Los Angeles . . *Past President's Night.*

Texas . . June 6 . . Fredonia Hotel, Nacogdoches, Texas . . *Family Week End.*

Western New York . . June 20 . . *Annual Stag Outing.*

Industrial Molten Metal Handling Equipment

for exceptional efficiency and dependability under heaviest production schedules



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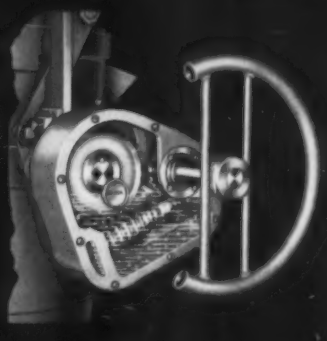

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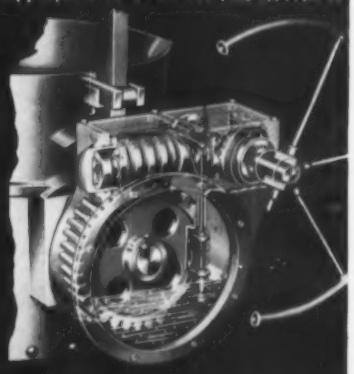

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Circle No. 178, Page 167-168

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exothermic anti-piping compounds for increased feeding efficiency

This bulletin tells you how. Send for your free copy today.

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New Improved Ceramic Shell Molds Cut Process Time 50% ...Material Cost 40%

You, too, can now enjoy the benefits of the complete Naicast mold making system like many leading investment casting foundrymen. Less process time...lower material cost...closer tolerances...larger castings...simpler methods, are some. Ask us for the full story. See how easily you can install this system to save time and money. No obligation, of course.

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Circle No. 179, Page 167-168

dietrich's corner

by h. f. dietrich

"I'm a nice guy." said one of the members of the group. "I help old ladies across streets. My neighbor is an old man. I shovel his snow. A few houses down the street lives an old couple. I cut their grass. But, I'll be damned if I'll help a competitor."

"That's right." said his friend. "I've been in this business for 30 years. It's dog eat dog. What I learned came the hard way. I'm not going to tell what I know."

"But why is it," said a third voice, "that you come to a convention willing to learn what someone else has to offer? Why do you read books and hire engineers unless it is to use ideas other than your own? Isn't it a little selfish to keep your experience to yourself?"

"No one has to tell me about the foundry business." said the second voice. "As long as I run it, my shop is going to run my way—same as it has for the last 30 years."

This, it seems to me, is a weak argument. There are at least two fallacies. In the first place, the first molder learned his trade over 6000 years ago, and there are a lot of things still unknown about the game. One man, by himself, couldn't learn all about it in 30 years. In the second place, I'll bet this old boy 8 to 5 that he isn't doing everything in the same way as he did it 30 years ago. If he did, he would be out of business. He learned from others, and he adjusted as he learned.

Doing things in the same way breeds tradition, and tradition breeds stagnation. The parts of the world which first started to work metals are today the most retarded in its development. Why? Because tradition has held them in a viselike grip of stagnation. They are using the same processes employed by their ancestors. They have kept the secret of working metals—the hard way. Unless we share the things we have learned, we will each flounder around in the tradition of a dead past.

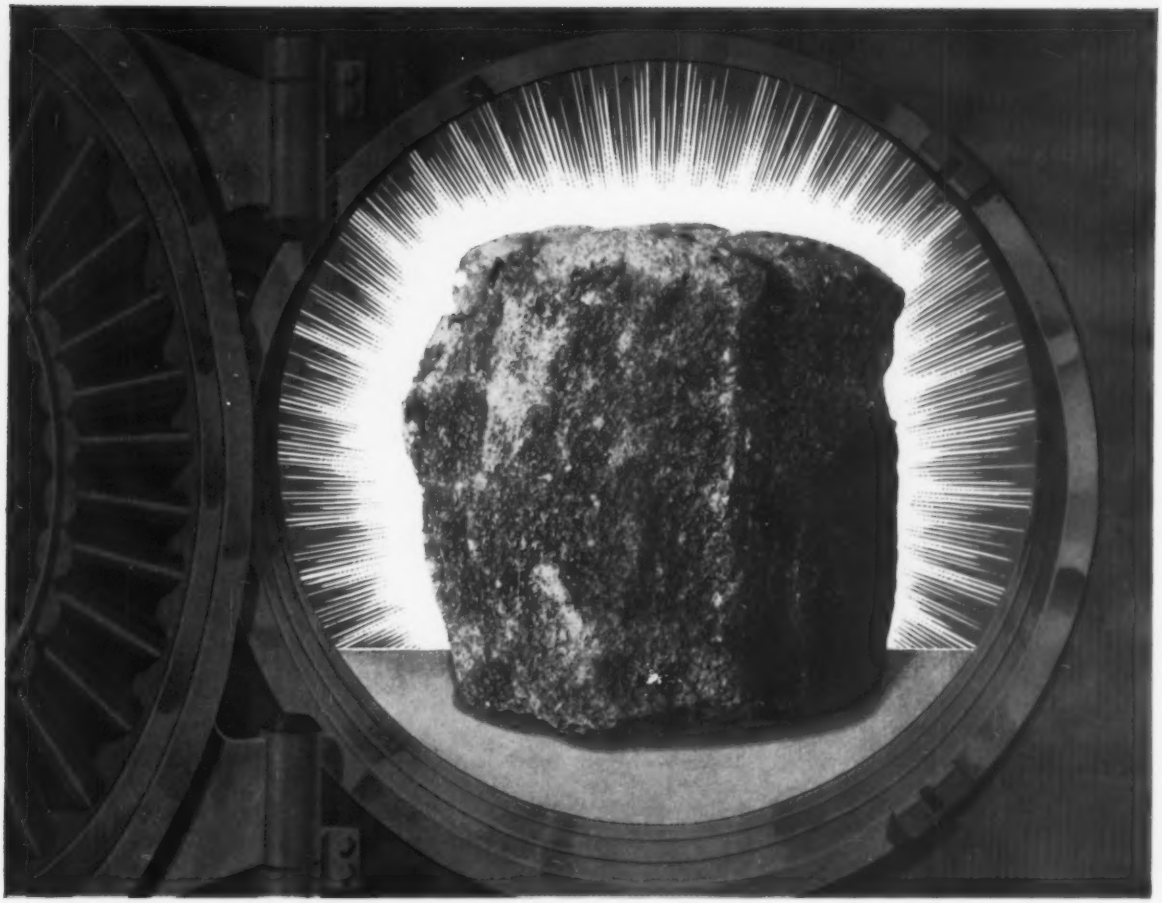
Another member of the little group objected to the free dissemination of cost facts. What's wrong with telling everyone how to figure costs? Such knowledge will prevent a pearl button maker from getting into the foundry game and going hog-wild with his bidding. Every one of these price cutting monkeys who goes broke because he doesn't know how to figure his costs, gives the foundrymen around him a rough time before he goes to the wall. It is better for everyone's business if true costs are known.

For the good of the industry, we must share our basic knowledge. Design engineers don't say, the Jones boys make good castings, and the Brown boys make bad castings. They say, a casting is good for the job, or a casting is not good for the job. Every bad casting that gets into the hands of the customer is bad for the industry regardless of source. The foundry industry doesn't have an airtight monopoly on design. Other manufacturing processes are willing to step in any time we fail. In self defense, we must see that everyone makes the best casting possible.

Do you think you have foundry secrets? If two people know it, it's no secret! Anything done in this world can be duplicated; if not today, at least by the day-after-tomorrow. A man doesn't live in a world by himself.

So, let's face reality. What's good for a casting—anyone's casting—is good for the industry.

they haven't invented a computer yet that has **all** the answers. Try **modern castings.**



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Buying coke from Semet-Solvay offers you other advantages, too: Four strategically located plants for fast, dependable service . . . coke that is quality-controlled from mine to cupola . . . services of metallurgical experts to assist on foundry problems.

If you are not already a user of Semet-Solvay foundry coke, why not find out right away how it can help you realize a hotter, cleaner, faster cupola operation? Just contact your nearest Semet-Solvay office or write directly to us for complete details.

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Allied Chemical

Circle No. 181, Page 167-168

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for the asking

Heavy-duty cart . . . is designed for easy dumping of coal, scrap, castings, etc. Folder No. 119. *Sterling Wheelbarrow Co.*
Circle No. 43, Page 167-168

Melting and holding . . . furnaces for non-ferrous metals shown with applications described in bulletin 551-A. *Lindberg-Fisher Div., Lindberg Engineering Co.*
Circle No. 44, Page 167-168

High aluminal plastic . . . designed for superior service under fire said to combine performance of high alumina composition with the convenience of plastic firebrick. Request bulletin No. 116. *North American Refractories Co.*
Circle No. 45, Page 167-168

Liquid resins . . . thermosetting, designed for rapid baking of cores, superior tensile strength and collapsibility. Technical bulletin F-2-R. *Reichhold Chemicals, Inc.*
Circle No. 46, Page 167-168

Sand muller . . . designed for CO_2 process completely detailed in brochure. *Carver Foundry Products.*
Circle No. 47, Page 167-168

Carbon-resistor tube furnaces . . . for temperatures up to 5000 F in 2 hr. Send for leaflet. *Hevi-Duty Electric Co.*
Circle No. 48, Page 167-168

Gas regulators . . . covered in 36-p booklet listing cylinder, manifold and station pressure types. *Air Reduction Sales Co.*
Circle No. 49, Page 167-168

Small electric hoist . . . designed for heavy duty completely detailed in 12-p brochure. *Chisholm-Moore Hoist Div., Columbus McKinnon Chain Corp.*
Circle No. 50, Page 167-168

Solid materials dispensing . . . unit designed to adjust carbon in metal as well as being useful in other foundry applications; covered in information report, 9 pp. *National Cylinder Gas.*
Circle No. 51, Page 167-168

Measuring microscope . . . pocket-size, 20 power, detailed in literature. *DuMaurier Co.*
Circle No. 52, Page 167-168

Film badge service . . . for monitoring personnel exposed to radiation fully discussed in folder. *St. John X-Ray Laboratory.*
Circle No. 53, Page 167-168

Foundry materials handling . . . equipment; curves, switches, turntables, transfer cars, pallet raiser and mold dump. Use circle number below for complete information. *Nomad Equipment Div., Westover Corp.*
Circle No. 54, Page 167-168

Ductile irons . . . booklet, 28 pp, is complete with information, applications and specifications of these new cast metals. *International Nickel Co.*
Circle No. 55, Page 167-168

Sieve shakers . . . for field, lab and production sieving or gradation operations are portrayed in brochure. *Soiltest Inc.*
Circle No. 56, Page 167-168

Cutting fluid . . . sulphur-free, for ferrous and non-ferrous metals. For literature, plus a 4-ounce sample, circle the number below on the Reader Service card, last page. *United Laboratories, Inc.*
Circle No. 57, Page 167-168

Testing instrument . . . bulletin features inclined manometer and other instruments necessary in determining gas velocity and static pressure. Three kits described. *Thermix Corp.*
Circle No. 58, Page 167-168

Heat treating . . . and processing furnaces; batch, automatic, continuous, gas, electric and oil discussed in brochure. *Sunbeam Equipment Corp.*
Circle No. 59, Page 167-168

Marketing considerations . . . for management offered in pamphlet based on Association's marketing symposium. Send for free copy. *National Association of Manufacturers.*
Circle No. 60, Page 167-168

Pneumatic grinders . . . new line of portable units fully detailed in loose-leaf catalog. *Thomas C. Wilson, Inc.*
Circle No. 61, Page 167-168

Testing center . . . described in 11-p brochure. Provided for industry by company for test cutting of actual work pieces submitted by customers before purchase of machine tools. *DoAll Co.*
Circle No. 62, Page 167-168

Grinding wheels . . . brochure features standard markings for grinding wheels and elaboration on characteristics; type of abrasive, size of cutting particles, grade of hardness, wheel structure and type of bond. *American Emery Wheel Works.*
Circle No. 63, Page 167-168

Sigma welding . . . instructions presented in 48-p booklet. *Linde Co.*
Circle No. 64, Page 167-168

Worm gear . . . speed reducers brochure features new type designed to operate in three positions. *Link-Belt Co.*
Circle No. 65, Page 167-168

Lease plan . . . involves leasing any combination of equipment as a unit for three to five years. Chart is available when you use the Reader Service card, last page. *Nationwide Leasing Co.*
Circle No. 66, Page 167-168

A-C motors . . . booklet gives concise selection data for motors from one through 200 hp. *Reliance Electric & Engineering Co.*
Circle No. 67, Page 167-168

Tens-50 aluminum . . . casting alloy brochure contains specifications, mechanical properties and casting technique. *Navan Products, Inc.*
Circle No. 68, Page 167-168

Cast alloys . . . in carbon, low alloy and stainless steel groups featured on data chart including design applications of each alloy. *Lebanon Steel Foundry.*
Circle No. 69, Page 167-168

Data card . . . for high temperature steels and alloys lists 19 special metals used in high temperature applications. *Allegheny Ludlum Steel Corp.*
Circle No. 70, Page 167-168

Air hoist . . . specifications for new line of hoists offered in brochure. *Yale Materials Handling Div., Yale & Towne Mfg. Co.*
Circle No. 71, Page 167-168

Welding equipment . . . brochure, 24 pp, evaluates 50 design features found in oxy-acetylene welding and cutting equipment and industrial regulators produced by 19 manufacturers. *Modern Engineering Co.*
Circle No. 72, Page 167-168

Eliminate porosity . . . in castings. This is subject of article in company publication regarding application of lithium copper cartridges for deoxidation of molten metal. *Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc.*
Circle No. 73, Page 167-168

Trash cart . . . eliminates shoveling and simplifies floor cleaning; operator wheels cart to waste, which is then swept into cart. Send for information. *Handling Devices Co.*
Circle No. 74, Page 167-168

Non-destructive testing and sorting . . . of accidentally mixed or incorrectly processed metal parts. New instrument designed for use with either ferrous or

Continued on page 144

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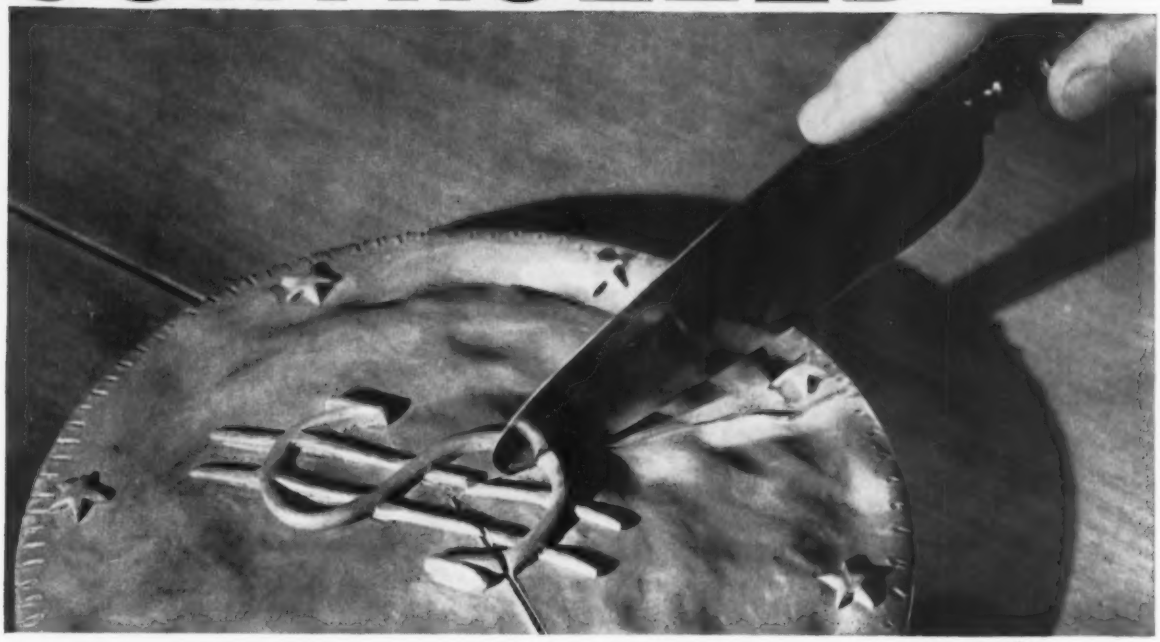

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If you now use hard (chilled) iron abrasives—and almost half of all abrasives used still fall into this category—may we suggest **CONTROLLED "T"®**, with its exclusive and unique properties?

No doubt you selected hard iron abrasives because you wanted: fast cleaning and cutting action (the ability to remove sand and scale) and the "keying" action (where the product will receive further processing). Disadvantages of ordinary chilled shot and grit, of course, lie in their rapid breakdown (causing high consumption) and in their extreme high hardness (causing excessive wear on blades, control cages, impeller, liners, etc.)

CONTROLLED "T"®, made to a specific BHN, is an "iron fist in a velvet glove." Its controlled specifications are such that you enjoy the speed and cutting action of chilled, without the disadvantages of rapid breakdown and high maintenance costs. Savings: as much as 50% on consumption, as much as 40% on maintenance! You can cut yourself a generous slice of profits with these important cost-cutting features of **CONTROLLED "T"®**. If this sounds like a fairy tale, try us! We won't upset your operations with a test, there is a simple and inexpensive way to tell. Cost-conscious customers have been enjoying these extra profits for over a decade!

If you are using ordinary annealed or steel abrasives, you'll want to try our **PERMABRASIVE®**, the pearlitic malleable shot and grit with a controlled hardness range that saves you money through faster cleaning and lower cost per ton. Or **PERMA-STEEL®**, the low cost "work-horse" of the long-life abrasives, may fit your special application perfectly to produce many of the same cost-cutting advantages.

FREE: *the* NEW *"Second Reader on the use of shot and grit." Write for your copy.*

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Sole manufacturers of Permabrasive® and Controlled "T"® abrasives.

Circle No. 182, Page 167-168

Control Foundry Chilling with
CHILL
KOOLHEAD
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CHILL NAILS and SPIDERS
Choose any style chill nail from jumbo to stubby; slim, medium, or horse nail blade; blunt, pointed, straight or 90° bent. Some types available in Stainless, Brass, Aluminum, Copper coated to order. Spider Chills, jumbo or horse nail legs—double or single. Available in various sizes and types; also made to your individual specifications.
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Circle No. 183, Page 167-168

FREE MARKAL PAINTSTIK!

We will send you without cost or obligation a MARKAL PAINTSTIK. They are available in various types suitable for marking on any kind of material. Hot surfaces up to 2100°F, also welding and heat treating. Cold surfaces down to −50°F, wet, dry, icy, oily, rough, smooth, acid or alkali. ***MARKS Are Permanent, Fadeproof, Weatherproof.*** Specify surface condition, material, temperature at time of marking.

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Company _____

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Circle No. 184, Page 167-168

for the asking

Continued from page 142

non-ferrous metals. Use Reader Service card, last page, for complete information. *J. W. Dice Co.*

Circle No. 75, Page 167-168

Venturi torch burner . . . offers 10 to 1 turndown with low-pressure gas. Send for data sheet. *Byrant Industrial Products Corp.*

Circle No. 76, Page 167-168

Rotary union . . . connection between stationary supply pipe and revolving machine cylinder designed to decrease wear and power consumption. Request bulletin. *Perfecting Service Co.*

Circle No. 77, Page 167-168

Weigh feeder machines . . . featuring rate settings from 3 to 300 lb discussed in 4-p folder. *Syntron Co.*

Circle No. 78, Page 167-168

Wax injection presses . . . hold about 60 lb of pattern wax, reportedly enough to cast over 400 lb of steel or brass. Circle number below on Reader Service card, last page, for bulletin WP58. *Alexander Saunders & Co.*

Circle No. 79, Page 167-168

Mold cavity coatings . . . colloidal dispersions said to result in more uniformly sound castings having smoother surface finishes. Send for bulletin, Vol 4, No. 1. *Acheson Colloids Co.*

Circle No. 80, Page 167-168

Chill nails . . . and spider chills for foundry use subject of folder detailing prices and specifications. *Standard Horse Nail Corp.*

Circle No. 81, Page 167-168

Complete foundry service . . . is what company officials term their process for production of castings. Brochure includes discussion of service plus physical properties of company's irons. *Sorbo-Mat Process Engineers.*

Circle No. 82, Page 167-168

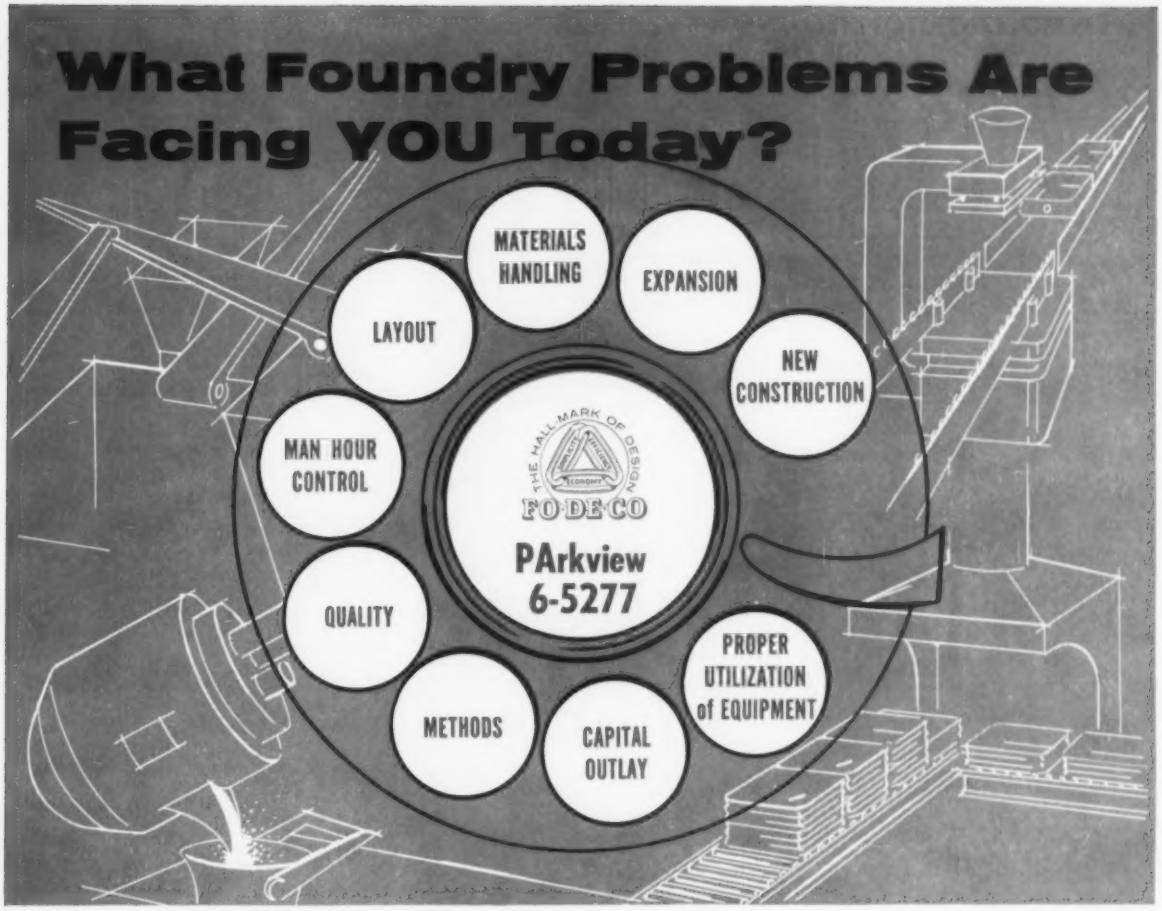
Die trim press . . . especially designed for the die casting industry discussed in literature available for the asking. *American Die Casting Machinery Co.*

Circle No. 83, Page 167-168

Pot crucible furnace . . . designed for heavy and continuous duty at all heat levels up to 2000 F for lab and pilot plant operations. Use Reader Service

Continued on page 146

skiers don't care . . but foundrymen want to know where they're going. For the straight scoop, circle these numbers on the **Reader Service** card, last page.



THEIR *Answers* ARE AS CLOSE AS YOUR TELEPHONE!

By contacting FODECO (Foundry Design Co.), you may bring into your plant immediately a foundry engineering service developed by experienced personnel who can offer design ingenuity for special purposes adaptable to your operations.

At all times the objective is to achieve maximum efficiency and coordination in melting—molding—coremaking—cleaning. With such coordination, foundry deficiencies are remedied and production increased. Complete foundry production layouts utilizing existing equipment or guiding alterations, expansion or selection of new equipment are fundamental functions of our service.

Let us arrange for you to visit any of the companies who have availed themselves of our service.

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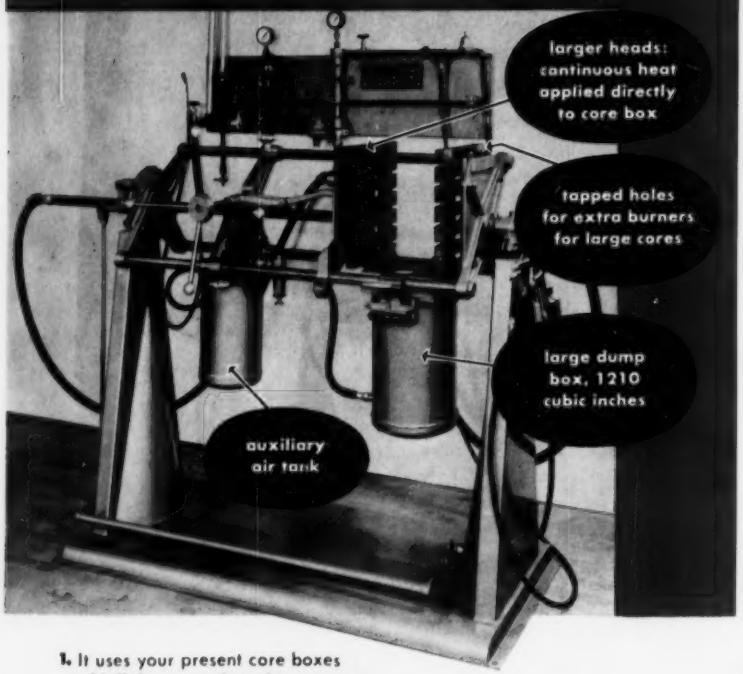
Circle No. 185, Page 167-168

Announcing the New 200 SERIES

'DEPENDABLE'

SHELL CORE MACHINE


larger heads: cantinuous heat applied directly to core box
tapped holes for extra burners for large cores
large dump box, 1210 cubic inches
auxiliary air tank

1. It uses your present core boxes with little or no alterations necessary. No need to build new core boxes.
2. Continuous heat applied directly to back of core box. Thin sections most desirable. Fast and efficient.
3. Operates on any type of gas, natural, manufactured, mixed or bottled. Economical.
4. Quick change for short runs. Clamps provided.
5. Produces intricate small cores in four gang boxes at the rate of ten per minute, and cores up to 14" diameters or 30" lengths at the rate of one per minute.
6. Various thicknesses of core can be obtained by length of time invested.
7. Eliminates the need for driers or pasting.
8. Shell cores produced offer Unexcelled Permeability . . . Collapsibility . . . Accuracy . . . Easy Shake-Out.
9. Low initial cost . . . $1770, F.O.B. Portland, Oregon.
10. Your Dependable Shell Core Machine comes completely equipped with accessories and assembled ready to operate. Just hook up to gas and compressed air lines. Shipping weight, crated, 500 lbs.

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DEALERS:

Frederic B. Stevens, Inc. *Detroit 16, Michigan*
Pennsylvania Foundry Sup. & Sand Co. *Philadelphia 24, Penn.*
Snyder Foundry Supply Co. *Los Angeles 58, Calif.*
Kramer Industrial Sup. *Denver 5, Colorado*
Sinclair-Brandt Co. *Houston 21, Texas*
Pacific Graphite Co., Inc. *Oakland 8, California*
Harold E. Pridmore *Los Altos, Calif.*
Don Barnes, Ltd. *Hamilton, Ont., Canada*
The Foundry Supply Co. *Minneapolis 14, Minn.*
Frank H. Jefferson, Inc. *Seattle 4, Wash.*
Sierra Foundry Supply Co. *San Gabriel, California*
Shallway International Corp., *Los Angeles, Calif., and Crawley, England*
W. O. McMahon *Birmingham 9, Ala.*
La Grand Industrial Sup. *Portland, Oregon*
St. Louis Coke & Foundry Sup. *St. Louis, Missouri*
Canfield Foundry & Eqpt. Co. *Kansas City, Kansas*
Smith-Sharpe Co. *Minneapolis 14, Minn.*

Circle No. 193, Page 167-168

for the asking

Continued from page 144

card, last page, for complete information. *Lindberg Engineering Co.*
Circle No. 84, Page 167-168

Epoxy compounds . . . are ready to use without addition of hardening agents. For technical data bulletin, use the Reader Service card, last page. *Houghton Laboratories Inc.*
Circle No. 85, Page 167-168

Cabinet ovens . . . in both horizontal and vertical air flow styles made in 500, 650, 850 and 1000 F series. Send for free information. *L & L Mfg. Co.*
Circle No. 86, Page 167-168

Versatile truck . . . designed to pick up, haul, dump or drop off any number of detachable containers ranging from flat bed to 40 cu yds. Complete information available. *Ingersoll Kalamazoo Div., Borg-Warner Corp.*
Circle No. 87, Page 167-168

Belt-driven fans . . . designed for quiet operation at slow speeds discussed in free literature. *Propellair, Div. Robbins & Myers.*
Circle No. 88, Page 167-168

Monorail drive . . . unit, electrically powered, reportedly will handle loads up to five tons at speeds to 2000 ft per min. Send for brochure. *Becker Crane & Conveyor Co.*
Circle No. 89, Page 167-168

Carbon determinator . . . semi-automatic, eliminates need of raising and lowering leveling bottle and of stretching to seat float valve. Send for bulletin. *Laboratory Equipment Corp.*
Circle No. 90, Page 167-168

Air service valve . . . achieves positive shutoff by means of spring-loaded rubber plug. Maintenance reportedly reduced to minimum. Send for details. *Rutherford Co.*
Circle No. 91, Page 167-168

Magnetic pulley . . . removes large and small tramp iron particles from foundry sand. Ceramic magnet material said to pull out imbedded tramp iron more efficiently than conventional magnet pulleys. Use circle number for manufacturer's literature. *Stearns Magnetic Products.*
Circle No. 92, Page 167-168

Variable-speed sheave . . . designed to eliminate corrosion as well as freezing and sticking. Free information is yours for the asking. *T. B. Wood's Sons Co.*
Circle No. 93, Page 167-168

Employees . . . how they can be better used to increase profits is subject of government bulletin. *Small Business Administration.*
Circle No. 94, Page 167-168

Coated abrasives . . . information kit includes buyer's guide, selector chart for metalworking and woodworking operations and brochures on these opera-

Continued on page 148

"It's the lowest cost alloy for ductile iron"

Foundries find that ELECTROMET magnesium-ferrosilicon is an economical, convenient source of magnesium for ductile iron. When added to a suitable composition, the alloy gives maximum ductility by promoting a matrix of soft ferrite. By adjusting the analysis, it can easily be used in high-strength irons having somewhat lower ductility.

Magnesium-ferrosilicon is available in grades with or without cerium. Cerium (0.5 or 2%) helps control unwanted residual elements which hinder the formation of spheroidal graphite. For further information and technical assistance, contact your UNION CARBIDE METALS representative.

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

Write for the folder, "Magnesium-Ferrosilicon for Ductile Iron."

UNION CARBIDE METALS

***Electromet** Brand Ferroalloys and other Metallurgical Products*

The terms "Electromet" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle No. 188, Page 167-168

Improve the physical properties of your aluminum castings with

Foseco® NUCLEANT

grain-refining compounds

This bulletin tells you how. Send for your free copy today.

Foseco®
FOUNDRY SERVICES, INC.
2000 Bruck Street, Columbus 7, Ohio

Circle No. 187, Page 167-168

Quality UP
Cost DOWN
through
"Statistical Quality Control for Foundries"

128 pp. 15 tables
6 figures
Chapter titles include:

- Sand Control Applications
- Melting Practice
- Quality Control Applications in the Coreroom
- Applications in Molding Practice
- Pouring Practice
- Installing the Quality Control System & Training Personnel
- Calculations Involved in Quality Control
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Member Price $4.50
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order from:
American Foundrymen's Society
Golf & Wolf Rds.,
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AIRETOOL GRINDERS SAVE PRODUCTION TIME

Airetool pneumatic grinders cut production costs because they speed up big metal removal jobs. They're powered by high torque air motors that won't slow down or stall in constant use . . . no matter how tough the job is. Yet they are easily handled and maneuvered. Operators get more work done without extra effort. Two horizontal models, 8" and 6" wheels; two vertical models, 6" wheel and 7, 8 and 9" disc wheel. Write for Catalog 67. Airetool Manufacturing Co., Springfield, Ohio.

REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Puerto Rico, Italy, Japan, Hawaii.
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AIRETOOL MANUFACTURING COMPANY SPRINGFIELD, OHIO

Circle No. 189, Page 167-168

for the asking

Continued from page 146

tions. Use circle number below for free kit. *Carborundum Co.*
Circle No. 106, Page 167-168

Power attachment . . . for portable elevating trucks described in 4-p bulletin. *American Pulley Co.*
Circle No. 107, Page 167-168

Portable pneumatic conveying . . . system illustrated in free booklet. *U. S. Hoffman Machinery Corp.*
Circle No. 108, Page 167-168

Jib cranes . . . described in folder with line drawings detailing construction features. *All-State Engineering Co.*
Circle No. 109, Page 167-168

Ear protectors . . . featuring new ear seal which covers conductive jawbone openings as well as ears. Send for brochure. *American Optical Co., Safety Products Div.*
Circle No. 110, Page 167-168

X-ray quantometer . . . offers quantitative analysis in two min. Send for new illustrated brochure. *Applied Research Laboratories, Inc.*
Circle No. 111, Page 167-168

free reprints

■ **The following reprints of feature articles which appeared in** MODERN CASTINGS **are available to you free of charge. Use the Reader Service card, last page.**

Strong molding sand . . . reprint from MODERN CASTINGS studies sieve ratios and processing techniques for high-strength sand mixes. *American Foundrymen's Society.*
Circle No. 112, Page 167-168

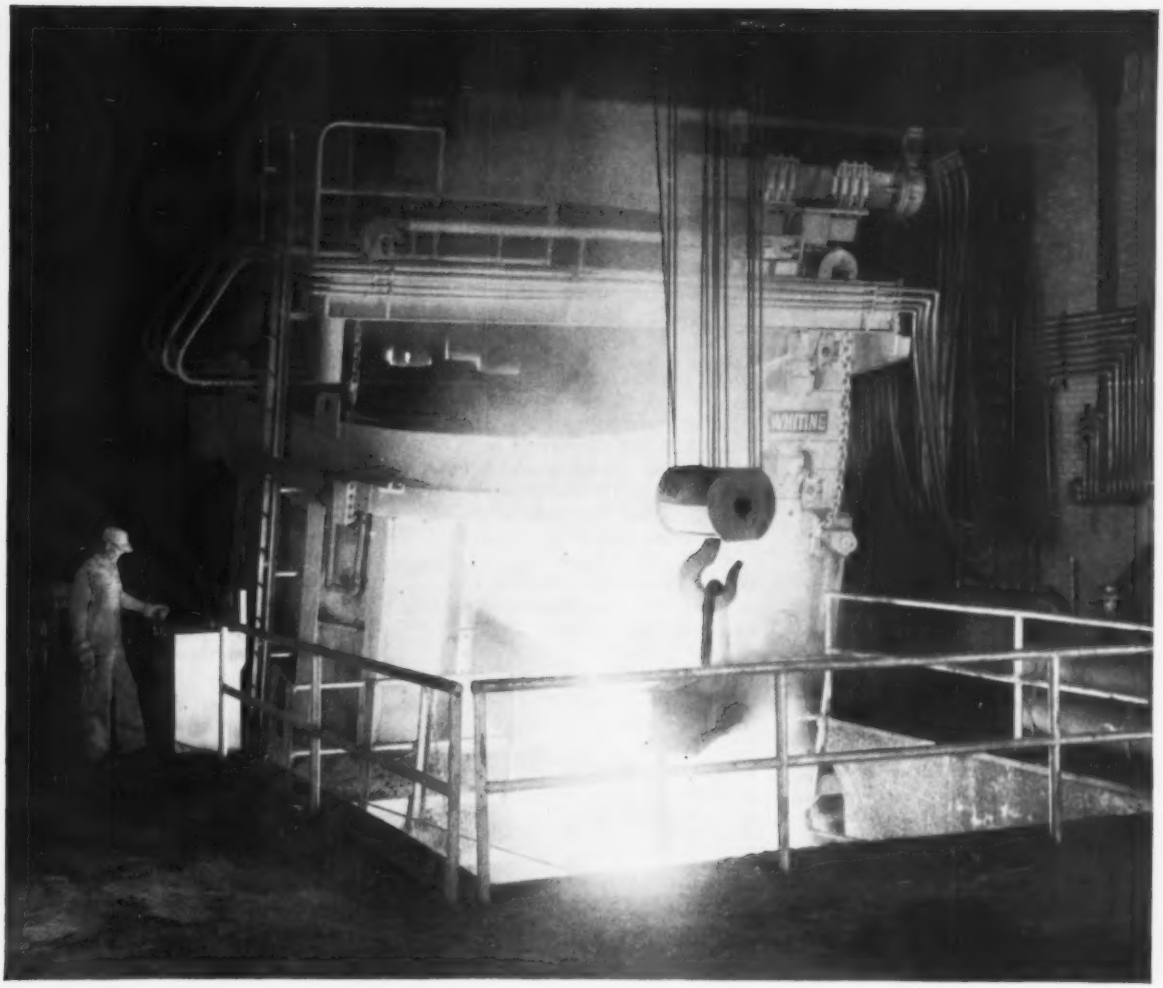
Parlanti Process . . . for casting metal by controlled rate of heat transfer is covered in MODERN CASTINGS reprint. *American Foundrymen's Society.*
Circle No. 113, Page 167-168

Aging practices . . . for high-strength ductile aluminum alloy HP-356 are covered in MODERN CASTINGS reprint. *American Foundrymen's Society.*
Circle No. 114, Page 167-168

Stainless steel . . . proved a profitable specialty for small foundry. MODERN CASTINGS reprint. *American Foundrymen's Society.*
Circle No. 115, Page 167-168

Nuclear reactor . . . fuel elements are successfully cast by method described in MODERN CASTINGS reprint. *American Foundrymen's Society.*
Circle No. 116, Page 167-168

Ladle linings . . . affect casting quality and production cost. Improved lining practices are described in MODERN CASTINGS reprint. *American Foundrymen's Society.*
Circle No. 117, Page 167-168



Hydro-Arc Speeds Texas Steel Production

Steel costs *can* be cut, by converting local scrap on the spot. Texas Steel Co. of Fort Worth, for example, now operates a 20-ton capacity Whiting Hydro-Arc electric furnace to produce billet-sized ingots ready for rolling. The very high efficiency of Hydro-Arc makes even medium or small scale operation profitable. This 12 foot 6 inch furnace energized with 7500 KVA substation equipment produces 23½ ton heats every 100 minutes. Whiting's superior electrode positioning control *constantly* keeps *proper* arc adjustment. Arcs burn at peak efficiency every moment. This means more heats per day at less cost.

An electric conversion installation can be surprisingly low cost, and highly profitable. For the full story, write for the Whiting Hydro-Arc Catalog, number FY-168. *Write today.*

The Whiting Corporation, 15628 Lathrop Avenue, Harvey, Ill.

87 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

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WHITING

FOUNDRY EQUIPMENT

MANUFACTURERS OF CRANES; TRAMBEAM HANDLING SYSTEMS; TRACKMOBILES; FOUNDRY, RAILROAD, AND CHEMICAL PROCESSING EQUIPMENT.

Circle No. 190, Page 167-168

foundry trade news

INVESTMENT CASTING INSTITUTE . . . has announced a cooperative research program under which each member firm will contribute one research study and in return will receive the completed studies of other member firms. A central Research Committee under the chairmanship of Dr. Jack Keverian, General Electric Co., has developed a listing of projects of concern to investment casters. Member firms will undertake projects appropriate to their available facilities. Twenty companies are currently cooperating in the research activity.

Kaiser, Mexico Refractories merge . . Kaiser Aluminum & Chemical Corp. and Mexico Refractories Co., Mexico, Mo., have announced agreement on a merger, subject to approval of stockholders of both companies. Mexico Refractories will merge into Kaiser Aluminum, and will operate as a division in conjunction with the Kaiser Chemicals division.

Vanadium, Keokuk merge . . . Vanadium Corp. of America and Keokuk Electro-Metals Co. will merge, subject to approval of stockholders of both companies. The plan calls for the merger of Keokuk into Vanadium Corp., but Keokuk would continue to produce and distribute its products under its own trade names.

Roger B. Sinclair Associates . . . newly formed consulting service at Larchmont, N.Y., offers aid in solving foundry management problems.

Buckeye Steel and Advance Foundry . . . have announced a mutual marketing agreement under which Advance Foundry, Dayton, Ohio, will represent Buckeye Steel Castings Co., Columbus, Ohio, in the automotive market.

Carborundum Co. . . . has announced plans to build a 3/4-million dollar pilot plant for its Research and Development Div., Niagara Falls, N. Y. General C. F. Robinson, president of the company, said that nine to 12 months will be required for construction of the building and installation of equipment. The Research and Development Div. is turning out new products which require ultra-high temperature processing techniques not available in the company's main operating divisions.

Wilson Foundry & Machine Co. . . . Houston, Tex. firm has closed its nonferrous foundry operation.

U. S. Reduction Co. . . . aluminum smelter has opened an office at Los Angeles, Calif.

Claude B. Schneible Co. . . . Detroit producer of dust and fume control equipment has purchased McDaniel Tank Mfg. Co., Holly, Mich.

Milwaukee Solvay Coke Co. . . . Milwaukee, is installing new crusher, conveyor and screening equipment. All sizes of the company's foundry coke will be double screened, reportedly providing more effective means for producing narrow limits in size, offering control advantages to cupola operators.

Sorbo-Mat Process Engineers . . . St. Louis, have licensed Combustion Engineering, Inc., Monongahela Works, Monongahela, Pa., and Liberty Foundry Co., St. Louis, to manufacture Sorbo-Mat controlled specification cast metals.

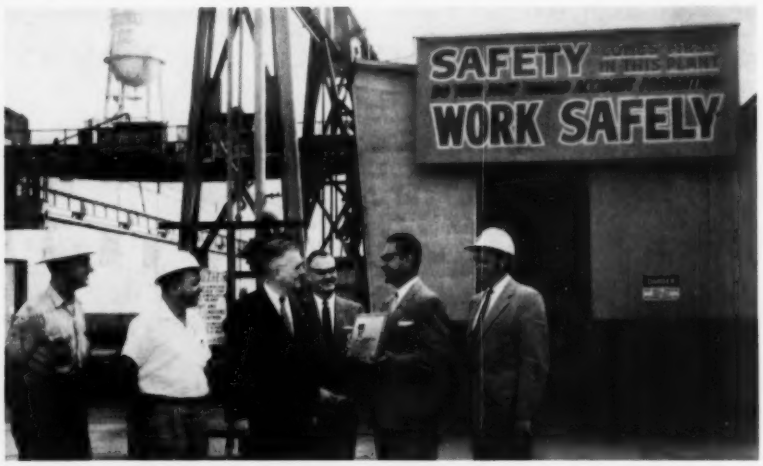
Crane Co. . . . Chicago firm will cease the manufacture of malleable and cast iron pipe fittings. Such fittings will now be purchased from other sources.

Doehler-Jarvis . . . division of National Lead Co. has been awarded a $46,700 Air Force contract to investigate effect of ultra high pressure on castings during solidification.

Alloy Precision Castings Co. . . Cleveland investment casting plant has been closed, but customers will be served by the parent Mercast Mfg. Corp. plant at La Verne, Calif.

Superior Foundry Inc. . . . Cleveland, announced purchase of Allyne-Ryan Foundry Co., good will and trade name. Both companies have been engaged in production of gray-

Continued on page 156



1,113,570 MAN-HOURS WITHOUT LOST-TIME ACCIDENT. National Supply Co. plant at Torrance, Calif., received the National Safety Council's Award of Merit for its outstanding safety record during 1958. From left to right, **L. McGhee,** maintenance man; **E. R. Treloar,** maintenance foreman; **J. D. Spalding,** plant works manager; **G. C. Merkley,** plant manager; **J. N. Kaplan,** National Safety Council and **S. Staxrud,** superivsor of plant safety. The plant foundry was presented the Steel Founders' Society Safety Award based on lowest frequency of accidents. The foundry also received this award from 1951 through 1955. A few plant safety figures: tool grinding department, 16 years without lost-time injury; inspection department, more than a million man-hours without an *accident* during a 10-year period.

LINDBERG FISHER

This nameplate is on all the equipment anyone needs for melting and holding aluminum

Heat and aluminum have been Lindberg's babies for many years. If your product requires the application of heat to aluminum anywhere along the line, we can help you do the job. Lindberg-Fisher furnaces cover every requirement of "heat for aluminum" and embody the latest developments in the field. Many new design and engineering features make Lindberg-Fisher melting and holding furnaces, and accessories, the most modern equipment available to industry.

With Lindberg-Fisher furnaces too, you get the expert technical skills of Lindberg Engineering Company's staff of engineers, metallurgists, technicians, widely experienced in all phases of aluminum melting, casting and treating. Because Lindberg builds all kinds of melting equipment, gas—oil—electric (resistance, 60 cycle induction, arc, or high frequency) . . . we can intelligently and objectively recommend the proper type of furnace to suit your particular conditions and needs.

We can fit the latest melting and holding equipment into your production line efficiently and economically—helping you to manufacture your product to closer specifications, and at a lower cost. Consult your local Lindberg representative. You'll find him listed in the local classified telephone directories in major industrial areas.

Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard Street, Chicago 12, Illinois. Los Angeles plant, 11937 South Regentview Ave., at Downey, Calif. In Canada, EFCO-Lindberg, Ltd., Toronto.
Also factories in: Argentina, Australia, England, France, Germany, Italy, Japan, Scotland, South Africa, Spain and Switzerland.

On the following two pages we've illustrated and described the Lindberg-Fisher equipment that covers all your "heat for aluminum" needs. Will you please turn the page?

LINDBERG heat for industry

FROM THE VERY BEGINNING

Starting with alloyed ingot or molten metal delivery from the reduction cells, aluminum can be processed in a wide selection of furnaces.

In Melting and Holding Furnaces

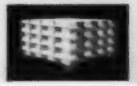
As shown in the flow diagram molten aluminum is delivered to either large capacity fuel fired reverberatory furnaces, or tilting two chamber induction furnaces for storage at suitable temperature . . . or alloyed ingot is melted and stored in similar furnaces . . . to provide an adequate supply of molten aluminum for the casting station area furnaces.

In Casting Station Furnaces

Molten metal received from the large storage or breakdown furnace described above or from smaller melting furnaces—again either fuel fired or electric, is received at the casting area, maintained at the correct temperature and processed into desired castings. Most of the holding furnaces illustrated can also be used for melting.

Many of the casting station furnaces shown can be equipped with the Lindberg-Fisher Autoladle for automatic ladling or hand ladling.

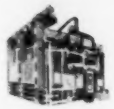
Hot Metal Delivery



Ingot

Fuel fired reverberatory, melting or holding. Charging well optional.

60 cycle two chamber induction, tilting; melting or holding.

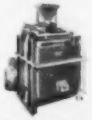


Fuel fired, double reverberatory melting and holding. Especially suitable for alloying. Charging well optional.

60 cycle, two chamber induction, tilting; melting and holding.

60 cycle induction coreless, tilting, especially for melting chips.

Fuel fired, crucible or pot, tilting, melting.

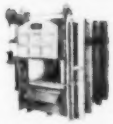


Electric resistance, "radiant muffle," Dry-Hearth, melting and holding, nitrogen atmosphere, especially for insert scrap.

High frequency induction, tilting, melting.

Autoladle for automatic ladling, four standard sizes available, up to 100 lbs.

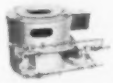
HYNI generator, low cost, high purity dry nitrogen.



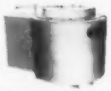
Fuel fired reverberatory, holding or melting.

Electric resistance, "radiant dome," reverberatory, holding.

60 cycle, two chamber induction, holding or melting, stationary.



Fuel fired crucible or pot, holding or melting, stationary.



Electric resistance, crucible or pot, holding or melting, stationary.

Fuel fired, Dry-Hearth, two chamber, holding and melting.

WHEREVER ALUMINUM NEEDS HEAT, LINDBERG-

A unique innovation is the Lindberg HYNI Generator... which supplies dry, high purity nitrogen economically, as a protective atmosphere for both melting and holding applications.

In Remelting Furnaces

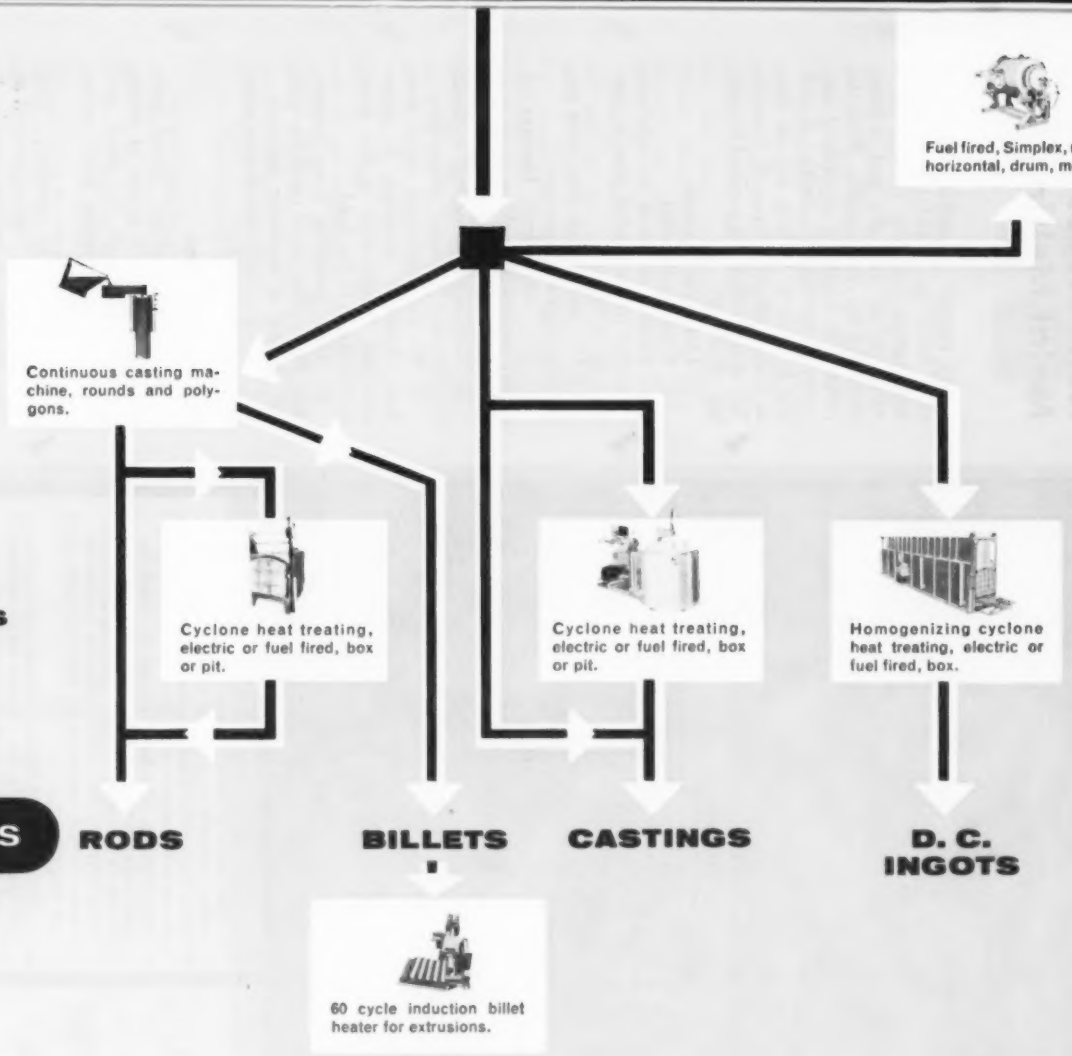
As the castings move out of the casting area for trimming, machining and finishing, the gates, risers, sprues, chips and scrap castings, etc., are returned to a remelt operation in one of the furnaces shown on the far right. These furnaces can be used for ingot meltings as well as for remelt operation.

In Heat Treating Furnaces

From the trimming and sorting station some castings are ready for direct use, others require suitable heat treatment as shown.

TO THE FINAL PRODUCTS

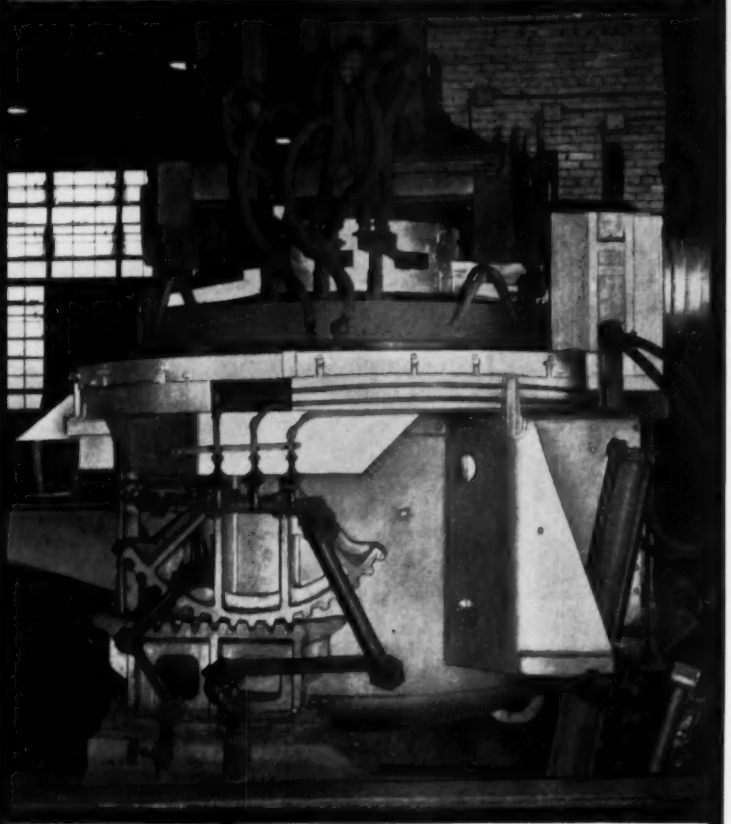
Lindberg can provide ANY furnace for your needs.


Fuel fired, Simplex, rotary, horizontal, drum, melting.
Continuous casting machine, rounds and polygons.
Cyclone heat treating, electric or fuel fired, box or pit.
Cyclone heat treating, electric or fuel fired, box or pit.
Homogenizing cyclone heat treating, electric or fuel fired, box.
RODS
BILLETS
CASTINGS
D. C. INGOTS
60 cycle induction billet heater for extrusions.

LINDBERG heat for industry

FISHER EQUIPMENT WILL APPLY IT MOST EFFICIENTLY

CONTROL ELECTRIC FURNACE FUMES



Pangborn offers a new concept in electric furnace exhaust hoods!

After years of development, Pangborn now offers effective control of smoke, fumes and dust from electric melting furnaces with minimum interference to furnace operations and maintenance. The hood design is based on the fundamental dust control principle of confining and capturing fumes and dust immediately adjacent the source. Effective control is secured with substantially reduced exhaust air volumes.

The Pangborn Exhaust Hood reduces the weight carried by the furnace roof; reduces hood areas subject to high temperatures; reduces electrode travel limitations and is applicable to top and side charge furnaces of all types and sizes.

With the exhaust hood connected to an efficient Pangborn Cloth Bag Collector, compliance with the most rigid air pollution control regulations is assured. For information call the Pangborn man in your area or write: PANGBORN CORP., 1300 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

Pangborn **CONTROLS DUST**

Circle No. 194, Page 167-168

Non-Ferrous Metal Melting

The purpose of melting is to provide metal in a suitable state for introduction into the mold with a minimum of difficulty and without impairing the metal quality. With this purpose in mind, the equipment necessary to provide this melting is endless in variety. Melting can be done in many different types of furnaces.

✓ The major difficulties evolved in melting consist of:

1) Dissolving of gasses.
2) Creation of oxides.
3) Control of metal temperatures.

✓ Several recommended general practices are as follows:

1) Use and charge only clean material of known composition.
2) Use only clean furnaces or clean crucibles for melting.
3) Melt as quickly as possible.
4) Melt in a near neutral to slightly oxidizing furnace atmosphere.
5) Do not super-heat metal more than absolutely necessary to insure adequate temperature as the metal is introduced to the mold.
6) After removing from furnace skim the molten metal carefully without stirring or excessive agitation.
7) Keep acurate temperature measurements of all melts.

Melting Practices

"Why good melting?" Good melting essentially is a means of saving money by virtue of: (a) lower melt losses and (b) higher good casting yield.

✓ Then follows the question, "What is good melting"? This is answered as, "the necessity of melting quickly, to melt enough metal when needed but not too much, and to provide metal when and where it is needed."

"Does good melting mean good melt quality?" The answer, of course, requires a definition of good quality. However, good melting invariably produces good quality and good quality is one step toward good castings. The recognition of good melting practice has been a problem.

✓ It is necessary in all cases to establish good melting by means of determining the quality of melt produced. This can be done by means of a fracture test similar to that designed by the American Foundrymen's Society, by chemical and mechanical properties as taken from test

by Harry C. Ahl
Malleable Iron Fittings Co.
Branford, Conn.

bars and by freedom from gasses and non-metallic inclusions.

✓ You can tell good melting by the cost of melting. High cost invariably results in bad melting. Low cost generally shows good melting.

Temperature control, where the metal is kept at a too high temperature, produces excessive oxide, excessive gasses, and the boiling of zinc, tin, lead and perhaps copper. Where temperatures are too low through no control, mis-runs, cold shots, etc., result.

✓ Fluxing is definitely not a cure for bad melting but is more a supplement to good melting practice. Fluxing consists of either chemical or mechanical treatment of the molten metal. Examples of mechanical treatment are the purging of a melt by an inert gas, or by letting the metal stand in the molten state or by the use of covers in certain alloys.

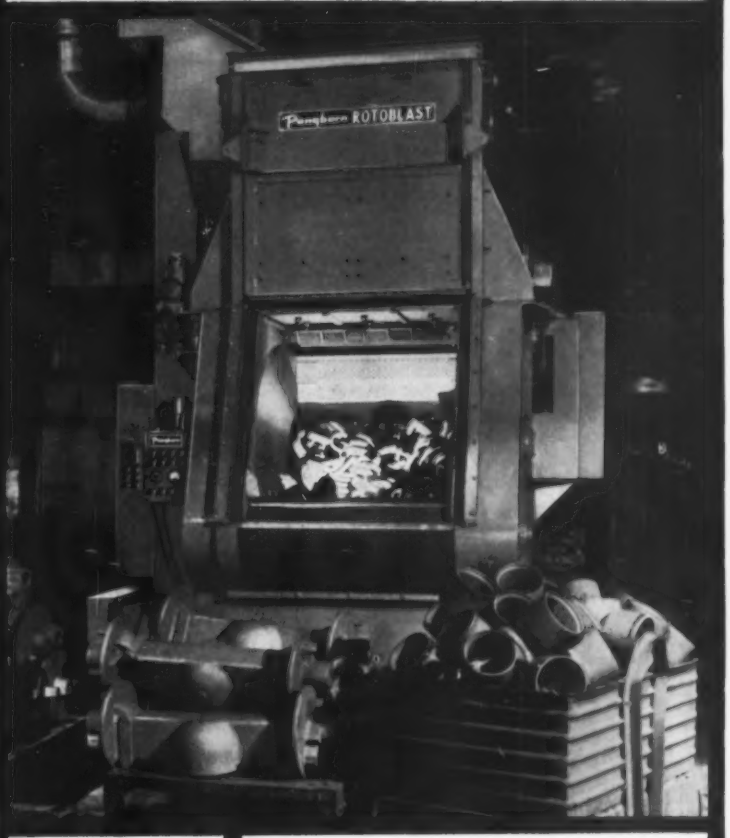
✓ Chemical fluxing is by the addition of various oxidizers or reducers such as phos-copper in the case of copper alloys or by the so-called oxidizing reduction process. Some molten metals require the use of reactive gasses such as chlorine in aluminum, or the hydrocarbon gasses in aluminum.

✓ "Do we have to flux?" The casting of pure copper requires fluxing with either phos-copper, calcium boride or lithium; and in the production of good gas free-aluminum alloys, chlorine gas may be necessary. However, fluxing is not a cure for bad practice ever and is not necessary in good melting practice if good melting produces high quality without the fluxes.

✓ As to the use of covers, in some alloys they are necessary. In the melting of nickel silvers, monels, etc., glass is a much used cover. In most copper base alloys however the use of a cover is not necessary. The use of charcoal can be dangerous in any metal inasmuch as it may be damp or may prevent the escape of mechanically entrapped gasses. In aluminum and some of the aluminum alloys, top covers may be necessary to prevent excessive oxidation.

Editor's note: This article contains highlights excerpted from a talk presented at the 1958 Purdue Metal Casting Conference.

CUTS MAN-HOURS 38%



Pangborn Rotoblast cuts man-hours per day from 24 to 15 at Meadville Malleable Iron

The investment in a new 20 cu. ft. Pangborn Rotoblast Barrel has really paid off for Meadville Malleable Iron Co., Meadville, Pa.! By switching from a competitive barrel of about 12 cu. ft. capacity, the firm now cleans loads three times as large in half the time. Today tote box loads averaging 1900 lbs. each are cleaned in 4—5 minute cleaning cycles. As a result, the Rotoblast Barrel has cut 24 man-hours per day to 15 man-hours in the cleaning department and greatly improved the quality of the work.

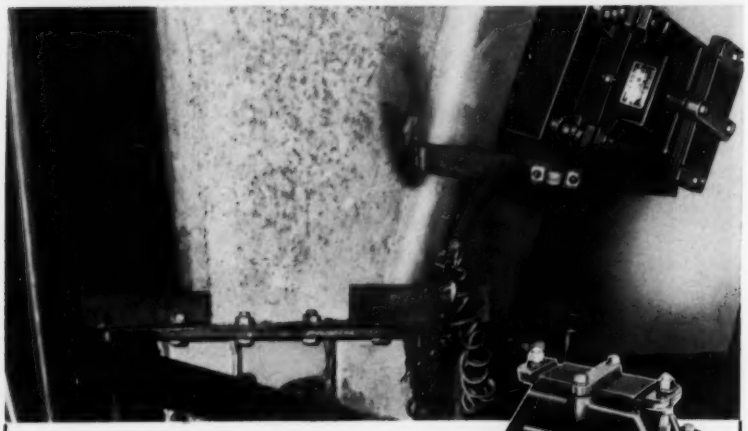
How much time and money can Pangborn Rotoblast save you? It would pay you to talk to the Pangborn man in your area. Or write PANGBORN CORP., 1300 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

Pangborn CLEANS IT FAST WITH **ROTOBLAST®**

Circle No. 195, Page 167-168

SYNTRON Pulsating Magnet

BIN VIBRATORS



—keep stubborn bulk materials flowing freely from bins, hoppers and chutes

SYNTRON Bin Vibrators assure a constant flow of foundry materials—scrap, alloys, sand, castings, etc. from storage and supply bins and hoppers to belt conveyors, screens, molds, and other equipment—eliminate equipment damage from pounding and poking.

Their 3600 powerful vibrations per minute will overcome the arching and bridging of the most stubborn materials.

Electromagnetic vibration is instantly adjustable to produce the best results.

Electromagnetic design means long, dependable operation and low maintenance.

Syntron bin vibrators are available in sizes for every job, large or small.

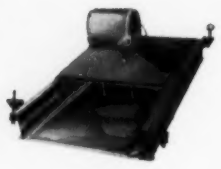
SYNTRON Bin Vibrators will save you many times their cost—

Write for free catalog data

SYNTRON COMPANY

545 Lexington Avenue Homer City, Penna.

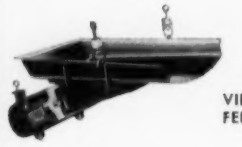
Other SYNTRON Equipment of proven dependable Quality



VIBRATING SCREENS

HOPPER LEVEL SWITCHES

DRY FEEDER MACHINES



VIBRATORY FEEDERS

MECHANICAL VIBRATING SCREENS

Circle No. 186, Page 167-168

foundry trade news

Continued from page 150

iron castings for automobiles, agricultural machinery, road building machinery, air-conditioning equipment, diesel engines and pumps. Operation of both foundries will continue under the name Superior Foundry, Inc.—with Allyne-Ryan Foundry Co. being a division. Frank Feltes, president of the latter, will remain in his present capacity.

Central Foundry Div. . . . General Motors Corp. Defiance, Ohio plant is currently casting over a million automotive front door hinges per month of malleable iron. Used on all 1959 GMC passenger cars, the malleable iron hinges replace hinges previously made of rolled steel sections. This conversion has eliminated shearing and forming operations required on the rolled steel sections and permits easier machining. In addition, the use of stress analysis in design has enabled the foundry to produce cast hinges which are lighter in weight and of better appearance.

Wah Chang Corp. . . . one of the country's leading refiners of tungsten and kindred metals, has been licensed by Stauffer Chemical Co. to operate the electron beam furnace to melt, refine and cast special metals at its Albany, Oregon plant. The furnace, designed and built by Stauffer-Temescal Co., will be capable of continuous melting and casting of high purity ingots—such as columbium.

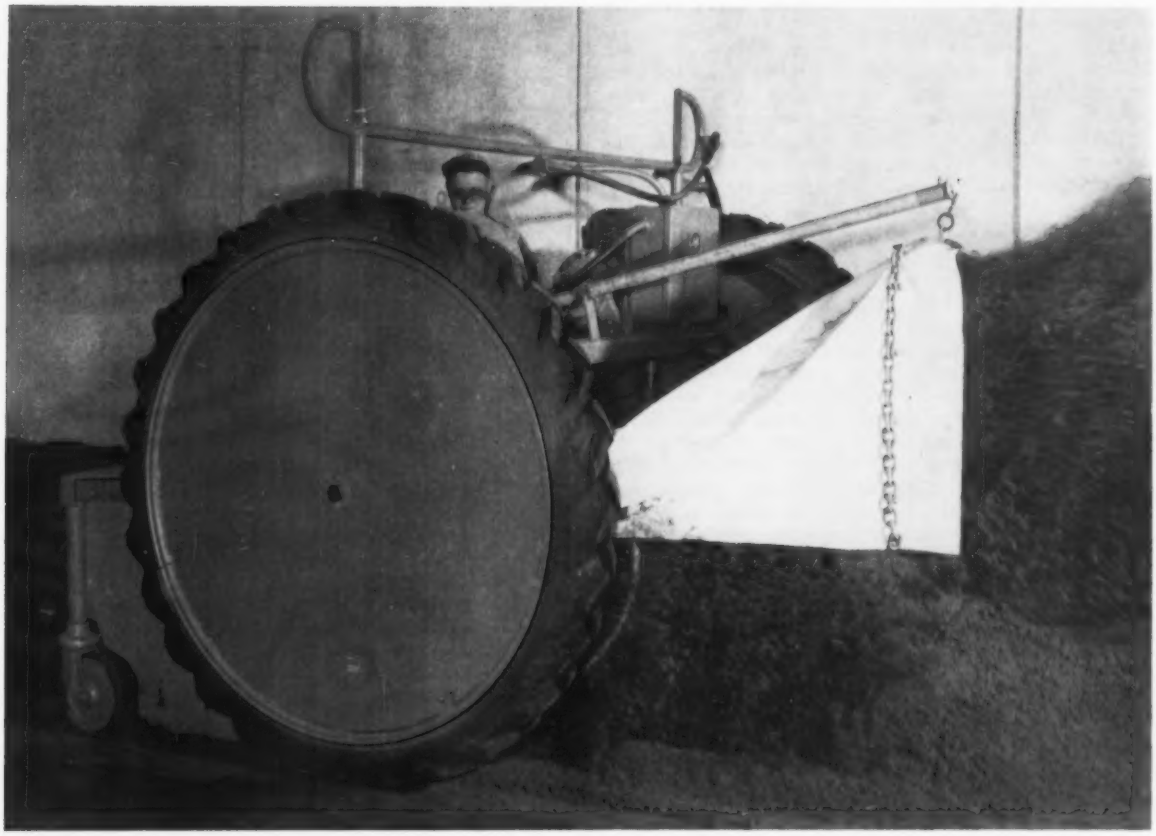
Air Heaters Inc., . . . Youngstown, Ohio, is a recently formed heating firm with a veteran staff. Officers of the company are: A. A. Olson, president; T. F. Schilling, treasurer; John Wehnhoff, secretary and Lee Wilson, member of the board.

When Olson announced formation of the firm, he said, "Industrial air heating has found many new uses for applications as cupola hot blast systems, jet engine testing, uranium mine ventilation and make-up air, etc. Dual purpose systems combining ventilation and plant heating are coming into general use." The main efforts will be directed to industrial plants and installations with requirements of from three million btu's per hour.

Metro Foundry Ltd., South Burnaby, B.C., has recently begun operations in bronze and aluminum-alloy castings, with C. I. Brett as president and F. G. Willis, C. M. McLennan and R. A. Bentley, officers. These

Continued on page 159

The New Moulders' Friend
FINDS FRIENDS EVERYWHERE



MOULDERS like The New Moulders' Friend sand conditioner, because the blending action of the rotary wire brush thoroughly mixes and aerates the sand, making it easier to put up more and better molds.

NIGHT CREWS like it, because it eliminates much manual labor and does a better job of conditioning the sand. With this completely self-propelled machine one man can condition more than two tons of sand per minute.

SAND CONTROL MEN like it, because it does such a thorough job of mixing, moistening and screening that they really can control the sand.

MAINTENANCE MEN like it, because it has few moving parts to keep in order.

YOU will like The New Moulders' Friend, because it pays for itself quickly with better castings and labor saved.

Investigate The Moulders' Friend today. See one in operation.

***The Moulders' Friend* — — Dallas City, Illinois**

Circle No. 197, Page 167-168

How to Prevent Hot Tears In Large Steel Castings

Application of every known corrective procedure for eliminating hot tears in susceptible large steel castings has paid off well in the Torrance, Calif., plant of The National Supply Co.

In the production of 18 press platens weighing 27,000 lb each, an average of 50 welding hours for each of the first three castings was reduced to a little more than one hour per piece for the last six castings.

Hubert Chappie, foundry superintendent, credited this achievement to five changes in foundry practice representing advanced techniques that are practical for any foundry. They are (1) the use of a sand that absorbs expansion (wood flour), (2) multiple gating of correct thickness, (3) external one-in. by six-in. chills, (4) favorable design, and (5) favorable carbon (0.40) to eliminate cracks.

Castings are 18 ft long, 7 ft wide and 22 in. high in the center. The ribs are one in. thick and the bottom plate is 1-3/4-in. thick, allowing 3/4-in. for finish. National Supply Company's engineering department was responsible for the casting design and cooperated with both customer and foundry to assure the right combination of rib strength and best practice in avoiding hot spots.

The job was an entire core assembly with a total of 20 large cores set in a 16 x 20-ft pit. Since platens were produced in lots of six, the cores were set on a concrete slab tilted to about 10 degrees for the pouring method used. The gate is down and the casting is poured uphill to avoid covering the entire drag with metal as it enters. The cope is thus protected from spalling.

Core rods and gaggers used in the cope promote cracks because of their expansion from heat. Expansion amounts to 0.1 in. per ft at 1200 F; the temperature often goes higher. Large cores are often over-rodded because no coremaker or core foreman wants to lose a core through breakage. However, the possibility of cracking makes it advisable to avoid over-rodding.

The importance of sand mix is shown by the fact that use of a 12 per cent silica flour facing sand on the surfaces of the pockets, backed up with wood flour, resulted in huge cracks at all ribs of the first casting. Cracks were reduced by eliminating the silica flour facing sand and using a sand with wood flour only. Resultant increase in penetration was prevented by lowering pouring temperature.

Sand with silica flour has high expansion which can be absorbed by wood flour in the backing sand. But unless there is enough heat in the metal to penetrate to the wood flour and burn it, it does not collapse. The ribs of the press platens, being only one inch thick, do not give off enough heat to produce this compensating absorption of expansion. A silica flour sand was used at surfaces nearest the gate. Wood flour sand was not used here because this hot spot would be susceptible to metal penetration.

Gate thickness in relation to contact thickness of the casting is also an important consideration in eliminating cracks. Usually, when a gate is thicker than the casting, the casting has cracks at contacts. Cracks are caused by a concentration of heat at the gates. By increasing the number of gate contacts from one or two on a large casting to eight contacts, cracks at contacts are eliminated.

Cracks near the gate may also be eliminated by repositioning the gate in such a way as to reduce the concentration of hot metal at the gate. Cracks were eliminated on press platen castings by placing 1-in. diameter chills 6 in. long at the corners on the gate side. Chills are made of copper, steel or graphite.

Pouring temperature was originally 2950 F because the metal has a long way to run, but satisfactory results were obtained later at 2850 F. Experience with large castings has indicated that the colder the pour the less the cracking. This practice also protects the sand from burning-in on the surfaces. Although a large casting could be poured so cold as to become wavy without affecting its utility, the appearance of a smooth casting was not sacrificed to this extent. A three-in. nozzle is used for pouring.

A shrinkage of 1/8 in. per ft was allowed on the first casting and all fillets were made one-in. radius. Shrinkage was then corrected to 3/16 in. per ft at the gate side and 1/8-in. was used on the opposite side.

Although all of these techniques improved the casting and reduced cracks, the most effective change was an increase in the carbon content of the steel from 0.23 to 0.40 per cent. Before this change each casting required approximately 20 hours of welding in the cracks. The first platen poured with 0.40 per cent carbon had no cracks. In making the last six castings with 0.40 per cent carbon, the total welding time was 7-3/4 hours. Most of this time was spent in welding where a head was cut low. Three of these castings had no welding. The significant conclusion to be drawn from this experience of National Supply Co. is that a review of known corrective foundry practices, and their application to any steel castings that are subject to cracks, will result in reduction or elimination of cracks.

PICKANDS MATHER & CO.

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IRON ORE • PIG IRON

COAL • COKE • FERROALLOYS

Circle No. 199, Page 167-168

foundry trade news

Continued from page 156

men constitute the Foundry Management of Industrial Engineering Ltd., who discontinued their Power Saw Mfg. operations in Vancouver.

Heat transfer problems . . . in melting, core baking, and annealing will be the subject of a workshop to be held June 22 to 26 at Columbia University under the direction of Professor Victor Paschkis. Details may be obtained by writing the Heat and Mass Flow Analyzer Laboratory, Room 624 Engineering, Columbia University, New York 27.

Duane Specialties, Ltd. . . . zinc alloy die cast firm has moved to a larger plant at 2 Johnson St., Newark, N. J. The expansion program will include additional machine capacity.

Tamms Industries . . . Chicago headquartered firm has reorganized to include its products for the metalcasting industry as a part of a new Flooring and Industrial Materials Dept.

St. Louis Die Casting Corp. . . . will open a new 30,000 sq ft die casting plant at Keokuk, Iowa, on Aug. 1. The plant will employ over 100.

Brown Thermal Development Co. . . . has changed its name to Brown Thermal Products Corp. J. W. Brown Jr., president, reports that the new name better identifies the scope of the company; in addition to development, the company manufactures, markets and services heat transfer products. Company operations are retained by Elyria, Ohio.

A. P. Green Fire Brick Co. . . . Mexico, Mo., has acquired, through an exchange of common stock, the Climax Fire Brick Co., Armstrong County, Pa. Climax production is principally that of fire-clay refractories, including Bessemer tuyers, rider tile, open hearth checkers, cupola blocks and high and medium duty fire-clay brick. No changes in operating staff are contemplated; the company will continue to produce its present line.

Scott Products, . . . Welland, Ontario, has been appointed sole Canadian manufacturers of Superflux Cupola Fluxing Briquets for Superflux Manufacturing Co., Allen Park, Mich. Sales in Canada will be handled by Canadian Hanson & Van Winkle of Toronto.

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Circle No. 200, Page 167-168

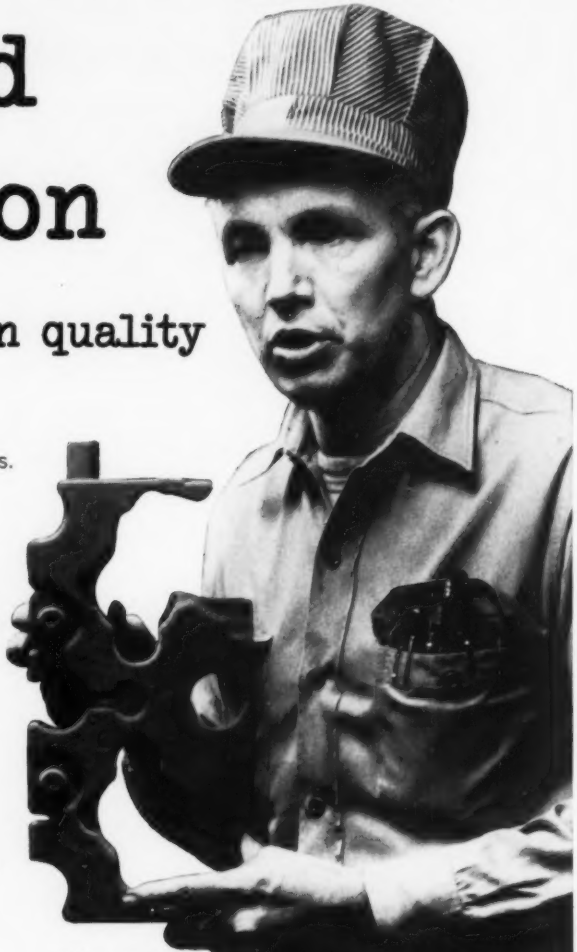
Report from Al Floyd, Assistant Core Superintendent, North Core Room, Golden Foundry Company, Inc., Columbus, Indiana:

We bucked the recession

by holding the line on quality

"The boss, George Stofer, and I talked it over many times. Could we beat the price squeeze by buying cheaper? We decided to stand firm on quality cores."

"This meant the continued use of high quality **LINOIL.** If we went to a cheap oil for intricate water-jacket cores like these, our scrap would go sky high. We like the added insurance of **LINOIL**... it helps hold our core scrap on heads and jackets to 2.06%. We think that's good!" "Our customers agree. That's another reason why Golden Foundry poured regularly throughout the slow-down period."



"Using regular lake bank sand, here's our mixture for these cores:

1% LINOIL
¾% Cereal
2% Iron Oxide
½% Silica
½% GREEN BOND Bentonite
2% Moisture

We bake them at 425° for 2½ hours."

Archer QUALITY

Archer-Daniels-Midland company

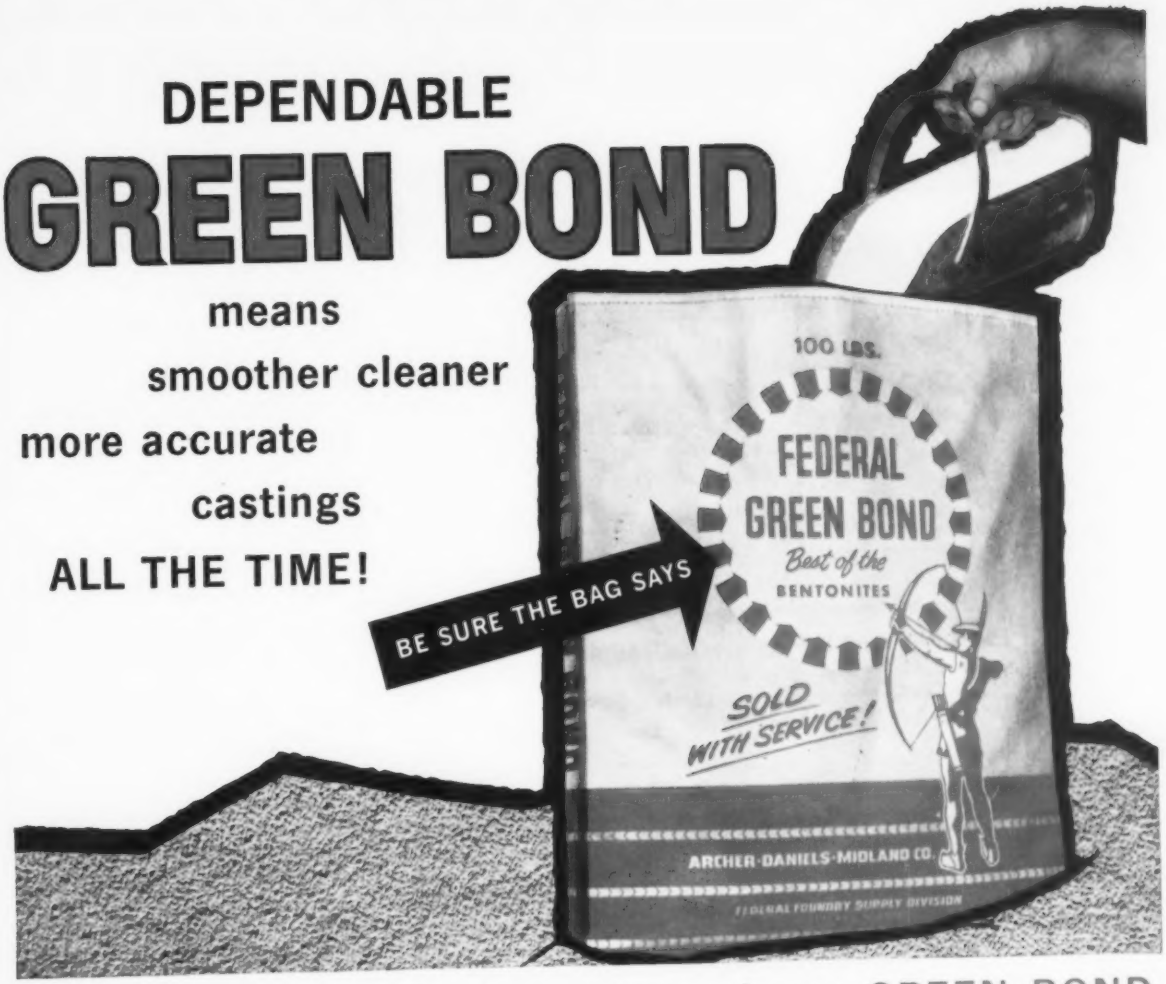
FEDERAL FOUNDRY SUPPLY DIVISION

2191 West 110th Street • Cleveland 2, Ohio

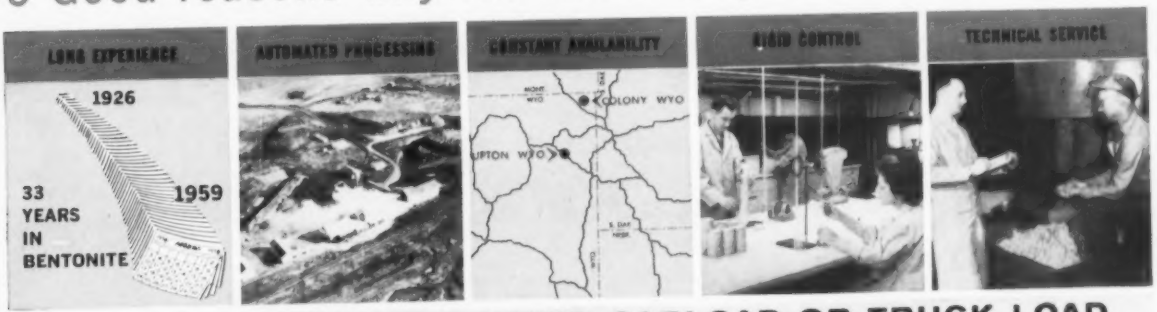
Circle No. 203, Page 167-168

DEPENDABLE
GREEN BOND

means
smoother cleaner
more accurate
castings
ALL THE TIME!



5 Good reasons why foundries rely on GREEN BOND



LET A-D-M MAKE UP A MIXED CARLOAD OR TRUCK LOAD

Send for
GREEN BOND
Technical Bulletin

Archer-Daniels-Midland company
FEDERAL FOUNDRY SUPPLY DIVISION
2191 West 110th Street • Cleveland 2, Ohio

Circle No. 204, Page 167-168

classified advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 25c per word, 30 words ($7.50) minimum, prepaid.

Positions Wanted . . 10c per word, 30 words ($3.00) minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 additional words.

Display Classified . . Based on per-column width, per inch . . 1-time, $18.00 6-time, $16.50 per insertion; 12-time, $15.00 per insertion; prepaid.

SALES REPRESENTATIVE WANTED FOR WESTERN SECTION OF PENNSYLVANIA. EXPERIENCED IN HANDLING COMPLETE LINE OF FOUNDRY SUPPLIES AND EQUIPMENT. FORWARD COMPLETE RESUME OF EXPERIENCES INCLUDING SALARY REQUIREMENTS.

ALL REPLIES HELD CONFIDENTIAL **BOX F-158, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

PLANT ENGINEERS

Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent protograph. All replies confidential. **Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERINTENDENT

Wanted superintendent for small non-ferrous sand castings foundry in Rockford, Ill. area. Must have complete knowledge and experience in melting, gating and rigging of patterns. Sand control and sundry practices of a sand castings non-ferrous foundry. Give full qualifications and references. **Box F-156, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED — EXPERIENCED MELTER for aluminum, bronze and magnesium foundry. Top pay and benefits. **ROSEDALE FOUNDRY CORPORATION, West John Street, Hicksville, L.I., N.Y.**

GOOD FOUNDRYMEN

when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.

Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.

For action contact:
John Cope
DRAKE PERSONNELL, INC.
29 E. Madison St.
Chicago 2, Illinois
Financial 6-8700

FOUNDRY METALLURGIST

Foundry metallurgist with B.S. degree, or equivalent technical knowledge, with experience in ferrous foundry operations. Must be capable of establishing controls for electric furnace melting and supervising metallurgical laboratory.

Desire person who has served apprenticeship in gray iron foundry, with practical knowledge of molding, coremaking and heat treating. Must be capable of assuming full charge of expanding metallurgical department and interested in attractive, long-term opportunities.

Salary open depending on experience. Fringe benefits above average, with noncontributory surgical, hospitalization and profit-sharing program. This is an immediate opening in Hagerstown, Maryland, with no traveling required. **Box F-153, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

CUPOLA FOREMAN

EXPERIENCED IN ALL PHASES OF GRAY IRON MELTING. Box F-157, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

INDUSTRIAL ENGINEER

Experienced in foundry operations as well as general industry. Capable of taking over management of industrial engineering division of ACME member consulting firm. Degree necessary. Age 35-45. Send complete details and include recent photograph. All replies held in confidence. **Box F-135, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES MANAGER

For Medium Size Gray Iron Foundry located in New England. Semi-captive. Must be able to discuss all phases of gray iron castings and have excellent record in establishing new and volume accounts.

Send complete resume on education and experience together with salary requirements. All inquiries will be held in strict confidence. Please reply to: **Box F-162, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

PLANT ENGINEER—Challenging opportunity to take charge of plant engineering and maintenance force of AAA-1 aluminum smelter. We prefer a minimum of five years experience in mining, smelting or foundry operation.

We are looking for a man who can set realistic standards of performance, analyze and reduce maintenance costs, recommend plant and equipment improvements and effectively organize and coordinate a department of 45 mechanics.

A good future for a good man.

Send resume to **Box F-164, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

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A completely modern electric furnace foundry specializing in shell molding of high strength alloy iron castings and brass castings desires to appoint MANUFACTURER'S REPRESENTATIVE in midwest and middle Atlantic states. Foundry can meet exacting specifications for physical properties, chemical analysis and microstructure. Men now calling on industrial accounts who require good production quantities of small castings are urged to write. List all qualifications, experience, current principals, etc. No objection to other non-conflicting foundry lines.

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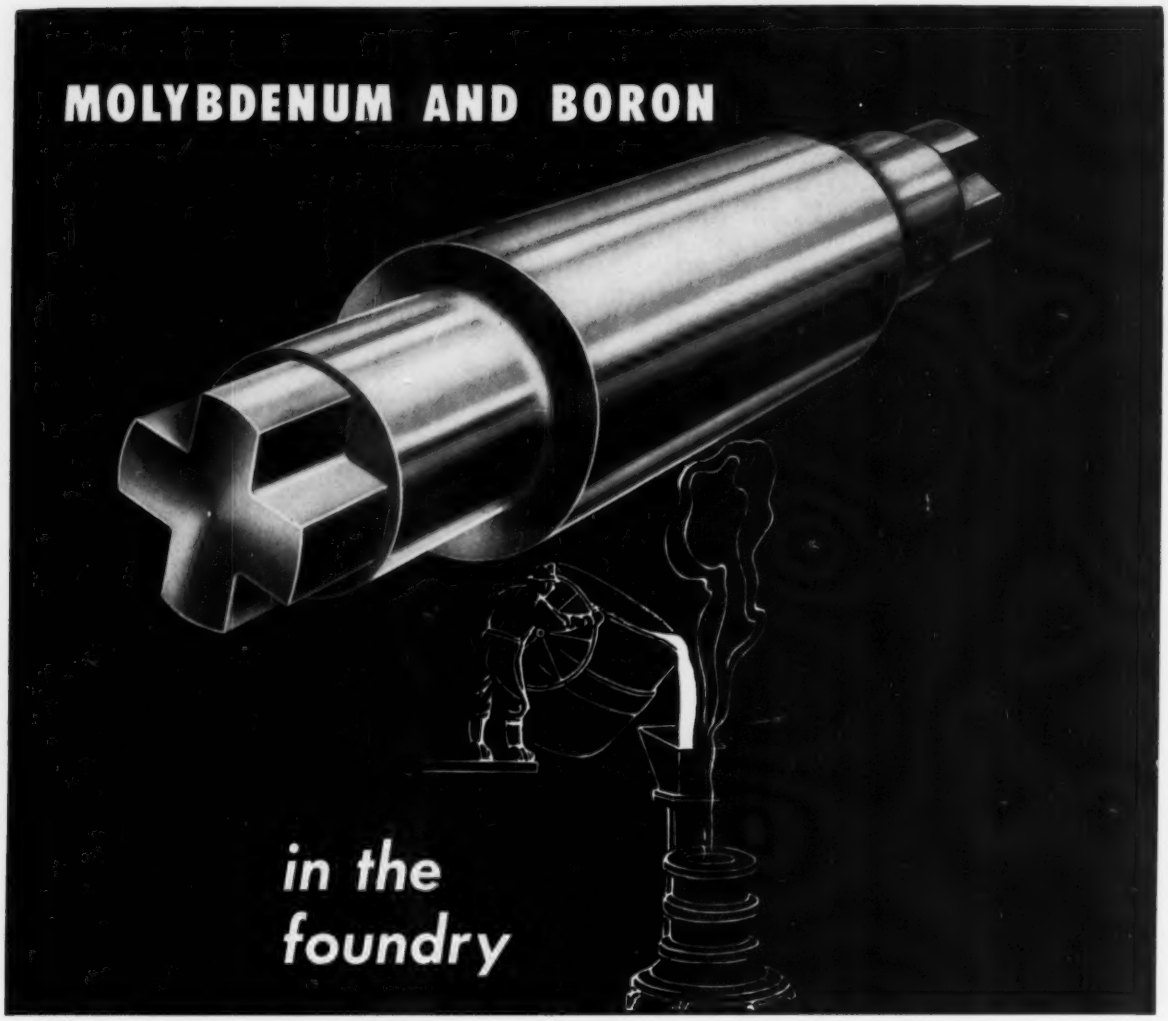

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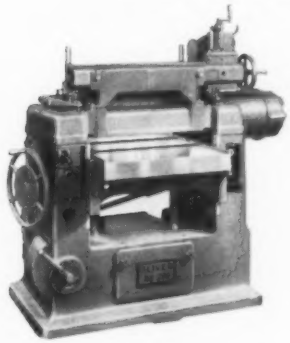

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Brussels Foundry Congress Technical Papers Available

■ Papers presented at the 25th International Foundry Congress held in Brussels and Liege, Belgium, Sept. 29-Oct. 4, 1958, are available in a bound volume. The 735-page compilation of technical papers is presented in language of the authors, with an abstract preceeding each paper. Each abstract is printed in French, German and English.

Included as one of the four papers presented by American and Canadian authors, is the official AFS Exchange Paper, *Adapting Theory to Practice in the Manufacture of Light Metals Castings,* by M. C. Flemings stitute of Technology. Write to Secretary, Association Technique de Fonderie de Belgique, 21, Rue des Drapiers, Brussel, Belgium.

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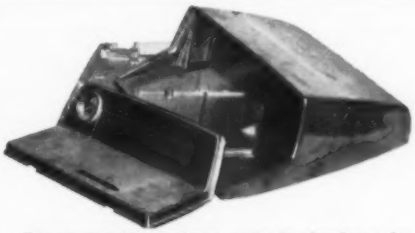

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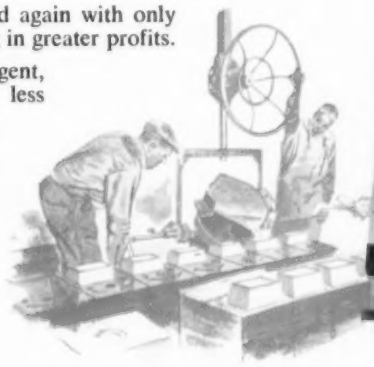

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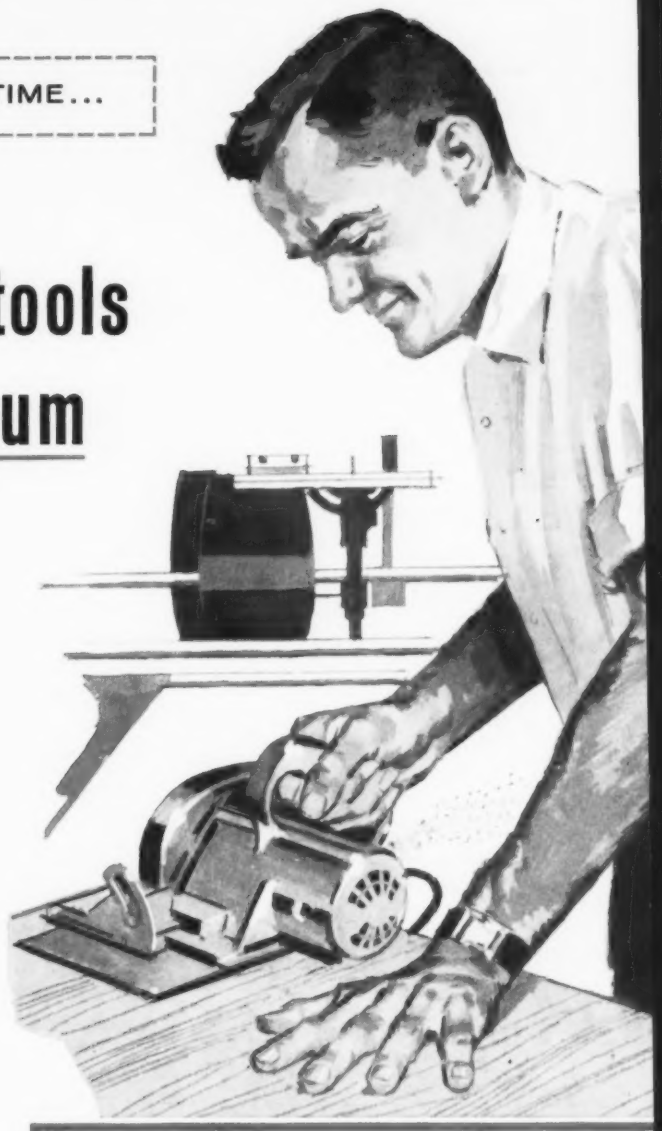

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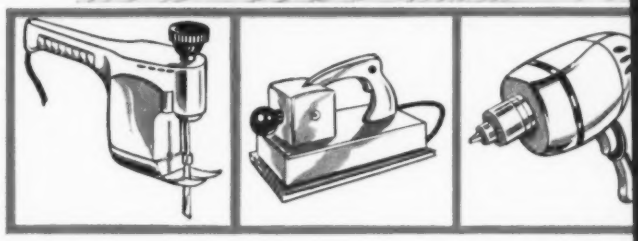

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